Essays on Dutch Disease and Exchange Rate Pass-Through: Evidence from Canadian Manufacturing Industries

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ABSTRACT

The dissertation consists of three essays on Dutch Disease and exchange rate pass-through. Dutch Disease refers to the adverse effects of the natural resource booms on the tradable sectors (manufacturing industries) which may occur mainly through the subsequent appreciation of the real exchange rate.

The first essay aims to investigate whether Canadian manufacturing industries have experienced Dutch Disease over the period 1992-2007 as a result of the oil boom. After a review of the literature and discussion of the theoretical considerations, the paper presents a two part empirical analysis to estimate the short- and long-run Dutch Disease effects for the Canadian manufacturing industries at three, four and few cases of five-digit levels of NAICS (about 80 industries), using quarterly data. The first part of the empirical analysis estimates the relationship between real exchange rate and energy prices as well as the other related factors and the second part estimates the effect of real exchange rate on output of the manufacturing industries. Based on these two estimated relationships, the Dutch Disease effect is derived by calculating the effect of energy prices on output of the manufacturing industries. The results indicate that the direction and magnitude of the Dutch Disease effect varies substantially across industries likely, as theory explains, because of differences in market structure in terms of the market power. Specifically, 53 out of the 80 industries suffer from the Dutch Disease with the elasticity of -0.18 in average, while Dutch Disease is beneficial for 24 industries with the elasticity of 0.21 in average. The simulation results reveal that, among the industries suffering (benefiting) from the Dutch Disease, each industry could have more annual output growth by 0.93 (-1.07) percent in average if energy prices remained at its level in 1992. This simulated value for the whole sample is 0.30 percent which is significant compared to 2.8 percent as the average of annual industrial production growth during 1992-2007.

The second and third essays together aim to model and estimate the degree of exchange rate pass-through into Canadian producer prices in manufacturing industries. The second essay, as a theoretical one, presents a literature review and contributes to the literature by developing a relatively more general theoretical framework. The provided model, which extends Yang's model (1997) by incorporating the role of the tradable inputs, is able to show all the major determinants of exchange rate pass-through together, while the previous studies have only analyzed the role of one or some of these factors. Specifically, the theoretical model indicates that the exchange rate pass-through should be between one and zero, while it is positively affected by the share of tradable inputs in total cost, and the domestic firms' market

share and negatively by the elasticity of marginal cost with respect to output. The sign for the degree of substitutability among the variants is not theoretically clear and remains as an empirical question.

Finally, the third essay presents the empirical framework for estimation of the exchange rate pass-through and its determinants in Canadian manufacturing industries. In this essay, the short- and long-run exchange rate pass-through elasticities to the domestic producer prices are estimated for the industries at three, four and few cases of five-digit levels of NAICS (about 100 industries), using quarterly data from 1992-2007. Then, the pass-through variation across industries is explained by regressing the estimated pass-through elasticities on the variables that are hypothesized to affect the pass-through elasticities according to the developed theoretical model. The results indicate that incomplete pass-through is observed in most cases although its magnitude is different across industries. The average short- and long-run pass-through elasticities are 0.24 and 0.36 respectively. The share of intermediate materials, as the tradable inputs, in production costs (with positive effect) and the elasticity of marginal cost with respect to output (with negative effect) are the most important determinants of the exchange rate pass-through across industries.

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Introduction

The Canadian energy sector has experienced solid growth in production and export values since the early 1990s accompanied by volatile increases in the Canada/U.S. exchange rates. The experience of other resource-rich countries, however, suggests that this oil boom could result in contraction of the tradable sectors (manufacturing industries) mostly through the subsequent appreciation of the real exchange rate. This phenomenon, which is called Dutch Disease in economics literature, can potentially lead to permanently lower rates of growth in the economy because the manufacturing sector is the source of innovation and technological spillovers. Therefore, it would be important to investigate the existence of Dutch Disease in the Canadian economy. The other important issue which has received great attention is the effects of recent significant changes in the Canada/U.S. exchange rate on the Canadian economy, particularly on the output prices of the Canadian industries. It seems examining the exchange rate pass-through (ERPT), which indicates the extent that Canadian output prices are affected by the exchange rate changes, can shed some light in this issue. This dissertation aims to investigate and provide some evidence on these two issues in the Canadian economy.

Following a brief introduction, the remainder of this dissertation is organized in three chapters. Chapter 1 empirically examines the Dutch Disease phenomenon in the Canadian industries. Chapter 2 deals with the theoretical aspects of the exchange rate pass-through and its determinants. Finally, Chapter 3 uses the developed theoretical framework in Chapter 2 as the framework for empirical analysis of the exchange rate pass-through and its determinants in Canadian Manufacturing industries.

The first paper examines whether Canada has experienced the Dutch Disease over the period 1992-2007 as a result of the oil boom. Since the early 1990s, the Canadian energy sector has experienced solid growth. Supported by investment, which has nearly doubled over this period, production output has significantly increased. Total oil production has increased by nearly 67 per cent from 89 million cubic meters in 1991 to around 150 million cubic meters in 2007, while natural gas production has increased by over 84 per cent from

113,490 million cubic meters in 1991 to around 209,362 million cubic meters in 2007.[1] As a result, Canada has become an important player in world energy markets and is currently the seventh and third largest producer of oil and natural gas, respectively. Canada's position of a net exporter of energy is expected to remain firm given plans to continue developing the vast oil sand deposits. The inclusion of these deposits would give Canada the world's second largest proven reserves (Issa et al., 2006).

The experience of the resource-rich countries suggests that natural resource wealth can be a double edge sword. On one side, it can help economic development and higher standards of living through raising national income. However, on the other side, it may lead to lower and unbalanced growth across the other sectors of the economy. There are two main areas of active research that justify the notion that there may be such a natural resource curse although, as Graham (1995) discusses, this thesis is not a widespread and general phenomenon. The first can be termed the political economy of resource rent generation and distribution. Based on this approach, the large windfall revenues from natural resources tend to give rise to rent-seeking behavior and fights over the distribution of these revenues, which in turn impede growth, as productive resources are drawn into nonproductive activities (Auty, 1994, p. 24).

The second research area—the one we will focus on in this paper—covers the general equilibrium effects of a resource boom which is known as Dutch Disease (DD) in economics literature. The term originally refers to the adverse effects of the natural gas discoveries of the 1960s on Dutch manufacturing, mainly through the subsequent appreciation of the Dutch real exchange rate. According to the Dutch Disease theory, part of the boom revenues is spent on the non-tradable goods which leads to an appreciation of the real exchange rate, which in turn draws resources out of the tradable sector (manufacturing) into the non-tradable sector (services), to the extent that this tradable sector is exposed to international competition. Moreover, the increased profitability of a booming sector bids up the prices of factors of production, which results in a contraction of tradable sectors due to the reduction in production factors. Considering that the manufacturing sector tends to be more innovative than other sectors and is a source of technological spillovers, Dutch Disease can potentially lead to permanently lower rates of growth in the economy.

The main purpose of first paper is to examine whether Canadian manufacturing industries have experienced the Dutch Disease over the period 1992-2007 as a result of the oil boom.

[1] Tables 126-0001 and 131-0001 of CANSIM are the sources of the data for the crude oil and natural gas, respectively.

While some studies (Macdonald, 2007; Bergevin, 2006) have analyzed the symptoms of the Dutch Disease in Canada (reduction in industrial production), there is no a systematic study of the effects of the oil boom on the Canadian manufacturing industries outputs. The results of this research are very important for policy makers.

If the Dutch Disease hypothesis (the negative effect of the oil boom on the productions of the manufacturing industries) is confirmed and policy makers recognize that this disease is costly for the economy, they can protect the economy from it by implementing the appropriate policies which have been successfully used in other countries such as Norway. These policies may include the investment use of the resource royalties to facilitate the growth of the tradable sector (investment in research and innovation), subsidies to maintain manufacturing output, saving the resource royalties in a Fund and use this saving to invest in the international financial markets, and limiting wage increases to the rate of growth in productivity of the manufacturing sector. However, it is emphasized that this study focuses on whether Dutch Disease exists rather than the normative question of what steps should be taken to mitigate these impacts. Moreover, examining the effects of the Dutch Disease on permanent growth rate is beyond the objective of this study.

Chapter 1 dealing with Dutch Disease is organized as follows. After the introduction in section 1.1, section 1.2 reviews some of the theoretical and empirical studies related to the Dutch Disease and presents their main results. Based on the major studies in the literature, section 1.3 explains the static and dynamic aspects of the Dutch Disease theory in detail. This section concludes that the expected negative effect of the Dutch Disease on outputs of the manufacturing industries as the tradables is based on this assumption that these industries are exposed to foreign competition and have little or no ability to set their own prices. The industries that cater for the home market as a result of trade protection or that possess monopolistic price-setting powers in their markets may benefit from the rise in domestic demand as a result of oil boom and therefore the Dutch Disease would be beneficial for these industries. This conclusion will be helpful for interpreting the empirical findings.

Section 1.4 specifies empirical and econometric methods, provides a description of the data used in the study, and presents the estimation results. The empirical work first, in subsection 1.4.1, estimates the relationship between real exchange rate and energy prices as well as other related factors using an error correction model and second, in subsection 1.4.2, the effect of real exchange rate on output of the manufacturing industries. Based on these two estimated relationships, we obtain the Dutch Disease effect by calculating the effect of energy prices on output of the manufacturing industries. The specified equations will be estimated using quarterly data during 1992-2007 for the Canadian manufacturing industries at 3, 4 and few cases of 5 digit levels of North America Industry Classification System—NAICS—(about 80 industries). The contribution of this empirical study is related to the level of disaggregation for tradable sector and control for unobservable or unmeasured factors, such as the emerging role of China in the world economy, affecting industrial reallocation in developed countries.

The summary and conclusions of Chapter 1 are presented in section 1.5. The results of the Dutch Disease effect (the effect of one percent change in energy prices on the output of each industry) indicate that 53 of the 80 industries suffer from this phenomenon with the elasticity of -0.18 in average (after control for all major determinants including the role of oil as an input). This reaction is zero for three industries and is positive for 24 industries with the elasticity of 0.21 in average. The simulation results reveal that, among the industries suffering (benefiting) from the Dutch Disease, each industry could have more annual output growth by 0.93 (-1.07) percent in average if energy prices remained at its level in 1992. This simulated value for the whole sample is 0.30 percent which is significant compared to 2.8 percent as the average of annual industrial production growth during 1992-2007. In general, the provided results indicate that Leather [316], Clothing [315], Textile mills [313], and Electrical equipment [335] industries suffer significantly from the Dutch Disease, while industries like Printing [323] and Chemical [327] may benefit from this phenomenon. This dichotomy is likely, as theory explains, due to differences in market structure in terms of the market power. This interpretation is supported by actual data measuring the market power in different industries.

The second and third papers, presented in Chapters 2 and 3 respectively, together aim to provide a framework for examining the degree of exchange rate pass-through into Canadian producer prices in manufacturing industries. In the past few years, exchange rate volatility between the US and Canadian dollars has dramatically increased. Ongoing large U.S. trade and fiscal deficits, the slow down in the dollarization of trade, and the global financial crisis, coupled with impacts of increasingly volatile oil, metals, and grain prices on the Canadian dollar as a commodity currency, suggest that Canada/U.S exchange rate could continue to be volatile for the foreseeable future. Considering that the United States is Canada's most important trading partner, the Canada/U.S. exchange rate can be a key economic factor that affects the prosperity of the Canadian manufacturing sector through changes in output and input prices. The significant appreciation/depreciation of the Canadian dollar in recent years has created great interest in the effects of these changes on the Canadian economy. It seems examining the exchange rate pass-through (ERPT), which indicates the extent that Canadian output prices are affected by the exchange rate changes, can shed some light in this issue.

Exchange rate pass-through (ERPT) is defined as the percentage change in local currency prices of tradable goods as a result of one percent change in the exchange rate between the home country and its trading partner. Complete ERPT refers to a one-to-one relationship between local prices and exchange rate changes while partial ERPT refers to a less than one-to-one response. The rate of the ERPT has important implications for the volatility of the real exchange rate as well as the effectiveness of the trade and monetary policies. Moreover, the exchange rate pass-through estimations help us to identify and understand those markets which are more at risk from large variations in exchange rates, which in turn can help in designing appropriate policies. The purpose of this study is to model and estimate the extent of exchange rate pass-through to domestic producer prices for three, four and few cases of five-digit NAICS industries in the Canadian manufacturing sector. Then, in the next stage, it identifies the factors explaining the pass-through variation across industries in manufacturing sector.

To examine the theoretical and empirical aspects of exchange rate pass-through and its determinants, the study is organized in two separate but related chapters. Chapter 2, as a theoretical paper, presents a literature review and contributes to the literature by developing a relatively general theoretical framework. Chapter 3, as an empirical paper, provides the estimations of the exchange rate pass-through elasticities and their determinants in Canadian manufacturing industries. The literature presented in section 2.2 suggests that the estimation of ERPT for manufacturing industries and primary products (such as agricultural products) requires two different theoretical frameworks and therefore model specifications. Primary products are goods which the products of different countries are close to identical, or near-perfect substitutes, and therefore the Law of One Price could be expected but this does not hold for manufactured products.

The provided theoretical framework in section 2.3, which extends Yang's model (1997) by incorporating the role of the tradable inputs, is a relatively more general model which is able to show all the major determinants of exchange rate pass-through together, while the previous studies have only analyzed the role of one or some of these factors. Specifically, the theoretical model indicates that the exchange rate pass-through should be between one and zero, while it is positively affected by the share of intermediate materials, as the tradable inputs, in production costs, and the domestic firms' market share and negatively by the elasticity of marginal cost with respect to output. The sign for the degree of substitutability among the variants is not theoretically clear and remains as an empirical question. Section 2.4 provides a summary and conclusions of Chapter 2.

Chapter 3 presents the estimation of the exchange rate pass-through and its determinants in Canadian manufacturing industries based on the theoretical framework developed in Chapter 2. After introduction in section 3.1, followed by model specification and data description in section 3.2, section 3.3 presents empirical estimations of the ERPT to the domestic producer prices for the Canadian manufacturing industries at three, four and few cases of five-digit levels of NAICS. In subsection 3.3.1, an error correction model (ECM) is used to estimate contemporaneous and short run pass-through elasticities, while the long run pass-through elasticities are derived from the cointegration equations. Then, in the second stage, the pass-through variation across industries is explained in subsection 3.3.2 by regressing the estimated pass-through elasticities on the variables that are hypothesized to affect the pass-through elasticities according to the developed theoretical model in Chapter 2.

The summary and conclusions of Chapter 3 are presented in section 3.4. The results indicate that incomplete pass-through is observed in most cases although its magnitude is different across industries. The contemporaneous pass-through is less than 0.40 for more than 90 percent of industries. The average contemporaneous pass-through elasticity for the sample is 0.21 while the average short (after two quarters) and long-run pass-through elasticities are 0.24 and 0.36 respectively. The results imply that, in general, firms absorb a considerable part of exchange rate movements by varying their mark-up. In fact, when domestic currency appreciates, domestic firms may be willing to sustain temporarily lower profits to maintain market shares, as long as profits are adequate. On the other hand, when domestic currency depreciates, domestic firms have this opportunity to increase their profit margins. The second stage regressions show that the share of intermediate materials, as the tradable inputs, in production costs (with positive effect) and the elasticity of marginal cost with respect to output (with negative effect) are the most important determinants of the exchange rate pass-through across industries.

Chapter 1

Has Canada Caught Dutch Disease?

1.1 Introduction

While Canada was a net importer of the oil until the early 1980s, in recent years, export sales have increased sharply with higher oil prices. The value of the crude oil net exports has increased from -2,194 million dollars in 1982 to 17,327 million dollars in 2007. Crude petroleum and natural gas currently represent about 75 percent of Canada's energy exports, with natural gas becoming relatively more important since the mid-1990s.[1] These trends reflect changes in world energy prices and the growth of US net external demand for oil and natural gas. They also reflect a change in Canada's energy policies after 1973 that promoted exploration and investment in this sector.[2]

Since the early 1990s, the Canadian energy sector has experienced solid growth. Supported by investment, which has nearly doubled over this period, production output has significantly increased. Total oil production has increased by nearly 67 per cent from 89 million cubic meters in 1991 to around 150 million cubic meters in 2007, while natural gas production has increased by over 84 per cent from 113,490 million cubic meters in 1991 to around 209,362 million cubic meters in 2007.[3] As a result, Canada has become an important player in world energy markets and is currently the seventh and third largest producer of oil and natural gas,

[1] Table 228-0041 of CANSIM is the source of these data.

[2] For example, Supply Management Program announced in December 1973 to achieve energy security through self-sufficiency, Oil Import Compensation Program announced in January 1974 to improve the security of supply, National Energy Policy announced in October 1980 which include a broad range of policy initiatives to enhance supply security, Western Accord announced in March 1985 which was aimed to deregulate domestic oil prices to enhance competition and investment in this sector. For more details, see Issa et al. (2006) and Natural Resource Canada web-site.

[3] Tables 126-0001 and 131-0001 of CANSIM are the sources of the data for the crude oil and natural gas respectively.

respectively. Canada's position of a net exporter of energy is expected to remain firm given plans to continue developing the vast oil sand deposits. The inclusion of these deposits would give Canada the world's second largest proven reserves (Issa et al., 2006).

The experience of the resource-rich countries suggests that natural resource wealth can be a double edge sword. On one side, it can help economic development and higher standards of living through raising national income. However, on the other side, it may lead to lower and unbalanced growth across the other sectors of the economy. There are two main areas of active research that try to justify the notion that there may be such a natural resource curse although, as Graham (1995) discusses, this thesis is not a widespread and general phenomenon. The first can be termed the political economy of resource rent generation and distribution. Based on this approach, one explanation is that the large windfall revenues from natural resources tend to give rise to rent-seeking behavior and fights over the distribution of these revenues, which in turn impede growth, as productive resources are drawn into non-productive activities. The other explanation is that resource rents tend to be volatile, which is bad for growth. Finally, it is said that the lax macro economic policies are tolerated longer (Auty, 1994, p. 24).

The second research area on the natural resource curse notion—the one we will focus on in this paper—covers the general equilibrium effects of a resource boom which is known as Dutch Disease (DD) in economics literature. The term "Dutch Disease" was used for the first time in The Economist (26 November 1977, pp. 82-3). The term originally refers to the adverse effects of the natural gas discoveries of the 1960s on Dutch manufacturing, mainly through the subsequent appreciation of the Dutch real exchange rate. The appreciation of real exchange rates makes the international competitiveness of domestic manufacturing industry worse and results in the manufacturing sector gradually deteriorating. This has also happened, in many similar cases, to countries endowed with rich natural resources (see Forsyth and Nicholas, 1983; Maddock and McLean, 1984). This phenomenon attracted a great deal of attention from the economic profession. The Dutch Disease phenomenon was first studied theoretically by Gregory (1976) and was followed by many others, including Snape (1977), Corden and Neary (1982), Corden (1984), Wijnbergen (1984,a,b; 1985), Krugman (1987), Sachs and Warner (1995, 2001) and Gylfason et al. (1999).

Corden and Neary (1982) presented the core model of Dutch Disease economics with three sector specifications, the resource sector, the non-resource tradable sector (manufacturing) and non-tradable sector (services), in order to analyze the effects on resource allocation, factor income and the real exchange rate of a boom in the resource sector in a small open economy. Within this model, the mechanism of the Dutch Disease is clear. Part of the boom revenues is spent on the non-tradable goods which leads to an appreciation of the real exchange rate, which in turn draws resources out of the tradable sector (manufacturing), to the extent that this sector is exposed to international competition, into the non-tradable sector (services). Moreover, the increased profitability of a booming sector bids up the prices of factors of production, which results in a contraction of tradable sectors due to the reduction in production factors. Considering that the manufacturing sector tends to be more innovative than other sectors and is a source of technological spillovers, Dutch Disease may lead to permanently lower rates of growth in the economy.

The main purpose of this study is to examine whether Canadian manufacturing industries have experienced the Dutch Disease over the period 1992-2007 as a result of an oil boom, where Dutch Disease takes the form of unbalanced growth across various sectors of the economy. In fact, this paper examines whether the productions of the manufacturing industries have negatively been influenced by the oil boom. While some studies (Macdonald, 2007; Bergevin, 2006) have analyzed the symptoms of the Dutch Disease in Canada (reduction in industrial production), there is no a systematic study of the effects of the oil boom on the Canadian manufacturing industries outputs. The results of this research are very important for policy makers. If the Dutch Disease hypothesis (the negative effect of the oil boom on the productions of the manufacturing industries) is confirmed and policy makers recognize that this disease is costly for the economy, they can protect the economy from it by implementing the appropriate policies which have been successfully used in other countries like Norway.

These policies may include the investment use of the resource royalties to facilitate the growth of the tradable sector (investment in research and innovation), subsidies to maintain manufacturing output, saving the resource royalties in a Fund and use this saving to invest in the international financial markets, and limiting wage increases to the rate of growth in productivity of the manufacturing sector. However, it is emphasized that this study focuses on whether Dutch Disease exists rather than the normative question of what steps should be taken to mitigate these impacts. Moreover, examining the effects of the Dutch Disease on permanent growth rate is beyond the objective of this study.

The remained of the paper is organized as follows. Section two reviews some of the theoretical and empirical studies related to the Dutch Disease and presents their main results. Based on the major studies in the literature, section three explains the static and dynamic aspects of the Dutch Disease theory in detail. The conclusions of this section will be helpful for interpreting the empirical findings. Section four specifies empirical and econometric methods, provides a description of the data used in the study, and presents the estimation results. The empirical work is a two part analysis. The first part estimates the relationship between real exchange rate and energy prices as well as the other related factors and the second part estimates the effect of real exchange rate on output of the manufacturing industries. Based on these two estimated relationships, the Dutch Disease effect is derived by calculating the effect of energy prices on output of the manufacturing industries. The specified equations will be estimated using quarterly data during 1992-2007 for the Canadian manufacturing industries. Section five presents summary and conclusions.

The contribution of this empirical study is related to the level of disaggregation for tradable sector and control for unobservable or unmeasured factors, such as the emerging role of China in the world economy, affecting industrial reallocation in developed countries. The previous studies have usually considered two sub-sectors in tradable sector: manufacturing and agriculture. However, the Dutch Disease literature emphasizes that this effect is very sensitive to the structure of each industry and therefore this level of aggregation can lead to biased results because of high cross-industry heterogeneity.[1] To address this issue, this study estimates the output equations for the Canadian manufacturing industries at 3, 4, and few cases of 5 digit levels of NAICS (about 80 industries). To control for the unmeasured factors, we will use U.S. as a control country (which is not an oil exporting country) and the output of each specific industry for this country will be considered as an explanatory variable. By entering this variable to the output equation, we can conclude that the observed symptoms (significant positive coefficients for real exchange rate) are indeed evidence of the Dutch Disease.

[1] See Pesaran and Smith (1995).

1.2 Literature Review pertaining to the Dutch Disease Studies

There is a growing literature dealing with different aspects of the Dutch Disease and resource curse (the negative relationship between resource abundance and growth). Since the focus of this study is on the Dutch Disease—the negative effect of resource boom on manufacturing industries—and an examination of the relationship between a resource boom and permanent growth rate is beyond the objective of this study, this section only reviews the major theoretical and empirical studies on the Dutch Disease.[1] In addition to providing a reference to compare our findings, this review helps us in considering the related variables and choosing the appropriate measure for them. At first, the theoretical studies are discussed and then empirical ones are presented.

1.2.1 Theoretical Studies:

Gregory (1976) is one of the first theoretical studies that models the effects of a resource boom on the economy (which was later called Dutch Disease). The main point of his partial equilibrium model is that mineral discoveries lead to an increase in export supply and that this brings an external surplus. The correction of this surplus by currency revaluation or by domestic inflation raises the price of non-tradable goods relative to the price of exports and imports. As a consequence import-competing and pre-existing export industries are squeezed. Snape (1977) criticizes the Gregory's model because of its partial equilibrium nature. He argues that, in this structure, the effects of changes in aggregate income and, hence, total demand changes on imports and exports are not considered. Moreover, the impacts of the mineral development on the costs of import-competing and pre-existing export industries are ignored. Therefore, using a general equilibrium structure, but still accepting Gregory's general assumptions, Snape modifies some of Gregory's conclusions regarding the impact of new mineral discoveries on the economy. He shows that although production of tradable goods other than minerals can be expected to decline, the production of some goods in this category may rise; and while the price of non-tradable goods can be expected to rise, their

[1] The resource curse is usually explained by the political economy of resource rent generation and distribution. For theoretical studies on resource curse see Wijnbergen (1984a, 1985), Gylfason et al. (1999), Matsen and Torvik (2005), Mehlum et al. (2006) and for empirical studies in this regard see Sachs and Warner (1995), Gylfason et al. (1999), Larsen (2005), and Mehlum et al. (2006).

production may increase or decrease.

Corden and Neary (1982) develop a core model where there are both direct and indirect de-industrialization effects of energy discoveries. They assume that there are three sectors in the economy, a booming sector (B), a tradeable sector (T) and a non-tradeable sector (N). The first two sectors produce tradeable goods given world prices, whereas prices for non-tradeable goods are given by domestic factors. Output in each sector is produced by a factor specific to that sector, and by labour, which is mobile between all three sectors. The direct impact of the boom on the economy is usually referred to as the Resource Movement Effect. The greater labour demand in the booming sector will lead to the movement of labour from T to B and, hence, will lower output in T directly. In addition, the movement of labour from N to B (at constant prices) will reduce the supply of N and create an excess demand for N, so that the price for N in terms of T will rise (a real appreciation) and further movements of resources out of T into N is expected (indirect de-industrialization). The other indirect effect (spending effect) is based on the idea that the boom results to an increase in the national income by raising the income of labour. This causes an increase in demand for both T and N sectors' products. Consequently, the price of the non-tradable goods will rise, while the prices of other sectors are not affected because they are determined in international market. This again induces real exchange rate appreciation which in turn, brings about an additional movement of labour out of T into N, reinforcing the indirect de-industrialization.

Although the simple model described above predicts that the tradable sector will eventually contract as a result of the expansion of the booming sector, there are several ways the core model may be altered. By changing some of the underlying assumptions, the predicted effects of the boom on the tradable sector may be less severe, and in fact, in some cases there may not be a Dutch Disease at all. For instance, as Cordon (1984) discusses, if one is initially in a situation where all domestic resources are not fully employed before the boom, the boom may actually provide a stimulating effect on the tradable sector.

Bruno and Sachs (1982) extend the Corden and Neary's core model by converting it to a dynamic model. They argue that the effects of the boom on the traded and nontraded goods sectors are inherently dynamic. A rise in wealth shifts demand from the tradable sector towards the nontradable sector and, hence, will cause profitability on capital in the two sectors to diverge and to differ from the rate of return given on world capital markets. Consequently, a process of capital accumulation in non-tradable sector and decumulation in the tradable sector will be expected. To account for this issue, they assume that physical capital flows freely between sectors and from abroad so that the marginal product of capital is always equal to the rate of return given on world capital markets. Under this assumption, they show that although the basic result of the Dutch Disease analysis is again confirmed, international capital mobility proceeds to the point where the relative price increase of nontraded goods is completely eliminated.

By assuming perfect international capital mobility, rational exchange-rate expectations and sluggish adjustment of domestic goods prices, Buiter and Purvis (1982) present an analysis of the macroeconomic consequence of an oil shock in the case that the country has some market power in the world market for its non-oil goods. This model abstracts from the role of non-traded goods and therefore non-oil goods refer to all domestically produced goods, including manufacturers and services. Moreover, they consider the implications of the oil shocks for nominal magnitudes in a fully specified monetary model. The result of this model is that increases in the price of oil or in known domestic oil reserves can have a transitional negative effect on non-oil goods output for a net oil exporter because of the possibility that the real exchange rate overshoots its long-run value. This overshooting results from the assumption that the price of the non-oil goods is predetermined and responds only sluggishly to excess demand or supply, while the nominal exchange rate (and hence the domestic price of the imported non-oil goods) adjusts immediately to maintain equilibrium in the asset markets.

The conclusion about the effects of an oil boom on non-oil goods applies to the aggregate of traded and non-traded goods and the likely shifts in the composition of domestic non-oil production cannot be handled in this model. To solve this problem, there is assumed to be a fixed world price for the country's non-oil exports and a non-traded good ("services"). By assuming that the services are more income elastic, the income and wealth increasing effects of an oil boom raise the price of services relative to all other goods whose world prices are given. Resources flow from manufacturing into services and deindustrialization occurs. However, in this model there is no reason to conclude that total employment and the value of total non-oil production would fall.

Wijnbergen (1984b) explains non-tradable goods and labor shortages in the Gulf countries, the decline of the tradable goods sector in oil producers (Dutch Disease), and the absence of employment benefits of higher oil revenues in Latin American oil producers using a disequilibrium model where real wages and the real exchange rate adjust slowly to clear the labor and non-tradable goods market. He concludes that the slope of the wage indexation line determines whether classical unemployment or repressed inflation results. Moreover, various policy measures are analyzed (details of this analysis have been provided in sub-section 1.3.1.3).

Hsieh et al. (1998), in a Dutch Disease model, endogenize the capital stock and labourleisure choice offering more flexibility on the supply side than previous studies which endogenize the capital stock only. Their main conclusion is that the Dutch Disease effect is magnified and when the non-traded goods sector is capital intensive the capital stock in the new steady state does not necessarily increase.

Hamilton and Hartwick (2008) set out a model of a small open economy exporting oil and a traditional exportable in return for produced capital. The small open economy also has local production of a non-tradable good. Their model shows that the size of the traditional export sector declines with an exogenous increase in the country's oil stock. The important result is that they arrive at the possibility of strong Dutch Disease, the case of the economy using less produced capital (all rented from abroad) after the oil stock discovery than it was using before the discovery.

In general, this review on the Dutch Disease literature indicates that deindustrialization—a decline in output and employment of the manufacturing sector—is exhibited as a result of resource boom in most studies. However, the deindustrialization is not necessarily coupled with real appreciation (increase in the price of the non-trade relative to traded goods). The real exchange rate could remain unchanged after the boom if capital is available from abroad at a fixed world rental. Moreover it should be noted that by changing some of the underlying assumptions the predicted effects of the boom on the tradable sector may be less severe, and in fact, in some cases there may not be a Dutch Disease at all. For instance, if one is initially in a situation where all domestic resources are not fully employed before the boom, the boom may actually provide a stimulating effect on the tradable sector or in the case that the industry is not exposed to foreign competition, it may benefit from the rise in home demand as a result of resource boom. The next subsection provides a review of the empirical studies pertaining to Dutch Disease.

1.2.2 Empirical Studies:

Here, we review some important empirical studies related to the Dutch Disease and present their main results. In addition to providing a reference to compare our findings, this review helps us in considering the related variables and choosing the appropriate measure for them.

Benjamin et al. (1986) show that the traditional two-sector model hides several of the interesting features that may arise from Dutch Disease. Using a multi-sectoral, computable general equilibrium model of Cameroon, they try to examine these effects in an experiment that injects $220 million of oil revenues into the Cameroonian economy. Specifically, they demonstrated that some tradable sectors may expand output despite the real exchange rate appreciation because of their linkages with the rest of the economy, as well as because of imperfect substitutability between domestic and foreign goods. Similarly, they show that, while wages rise from the oil boom, certain skill classes (particularly the rural unskilled) benefit less than others.

Looney (1990) examines empirically the Dutch Disease in Saudi Arabia for the period 1965-1985. He considers four sub-sectors in tradable sector (agriculture, mining, petroleum refining, and manufacturing) and four sub-sectors in non-tradable sector (construction; wholesale and retail trade; transport, storage and communications; and ownership of dwellings). The output of each sector is specified as a function of the variables that affect the expected profitability of that activity including the real exchange rate (between the U.S. and Saudi Arabia), the expected rate of inflation, the expected government consumption or investment, value added in oil sector as well as the expected non-oil GDP. The coefficient of the real exchange rate is interpreted as the effects directly related to Dutch Disease. The inflation term is an indirect Dutch Disease effect with higher anticipated rates of inflation decreasing the profitability of traded activities. For tradeable sectors, the Dutch Disease is present with the anticipated sign implying that the appreciation of the domestic currency has reduced output below the levels it would have otherwise been. The expected rate of inflation is significant for all four sectors. However, only agriculture and petroleum refining have the expected sign. For non-tradeable sectors except transport, storage and communications where its coefficient is not statistically significant, the appreciation of the domestic currency produces a stimulus to growth. Moreover, in all cases, increases in the expected rate of inflation provide an added stimulus to growth. In general, the results of this study confirm the Dutch Disease phenomenon (contraction of tradable sectors and expansion of the non-tradable sectors) in Saudi Arabia for the study period.

Hutchison (1994) uses the Johansen method of cointegration analysis and the vector error correction modelling (VECM) approach to empirically assess whether the development of the oil and gas sectors systematically had adverse effects on the manufacturing sectors in the Netherlands, the UK, and Norway. In his model, he controls for the independent effects of restrictive monetary policies, actual physical output measures for oil and natural gas, worldwide increases in energy prices and real exchange rate appreciations; factors which may have played important roles in the deterioration of manufactures. Quarterly data is used, and the variables are measured in natural logarithms. The sample time periods are 67:2-89:2 for the Netherlands, 71:3-89:1 for Norway, and 76:1-89:2 for the UK. The results of the cointegration and related VECM statistical analysis do not support the view that manufacturing decline is systematically and predictably related to energy booms, either for the short- or longer-term horizons.

Usui (1997) attempts to provide a comparison between Indonesia and Mexico in their policy adjustments to the oil boom with special reference to the Dutch Disease. The main conclusion is that Mexico provides a clear-cut example of the Dutch Disease thesis, but Indonesia is an exception. This comparison shows a striking contrast, especially in their fiscal, foreign borrowing, and exchange rate policies, and confirms the conventional understanding that a booming government should be conservative, as was the case in Indonesia, in its macroeconomic management to avoid Dutch Disease. Equally significant, investment use of oil revenues to strengthen the tradable sector is another factor responsible for Indonesian success.

Bjϕrnland (1998) analyzes the economic effects of the oil and gas sector (energy booms) on manufacturing output in two energy producing countries: Norway and the UK. He specifies a VAR model consisting of manufacturing production, oil and gas extractions, real oil prices, and the inflation rate (calculated from the GDP deflator). He estimates the model using quarterly data from 1976:1 to 1994:3. The results show that there is only weak evidence of Dutch Disease in the UK, whereas manufacturing output in Norway has actually benefited from energy discoveries and higher oil prices. He discusses that this fact actually emphasizes the role of government policies in oil producing countries in reaction to external energy shocks. Although the oil sector plays a much larger role in Norway than in the UK, macroeconomic policy has also been conducted very differently in light of the two major oil price shocks in Norway and the UK. In Norway, there were considerable subsidies to maintain manufacturing output over the transitional period of North Sea oil, and as a result, the rate of unemployment has remained much lower in this period. A similar benefit could maybe have been derived in the UK, from direct investment of the oil revenues in industries. Instead, with factory closures and rapidly increasing unemployment rates, much of the revenue from the North Sea in the UK went into social security.

Mogotsi (2002) shows empirically that Botswana did experience Dutch Disease (as a result of its diamond boom of 1982-90), as evidenced by a real exchange rate appreciation, the effect of which was a decline in some manufacturing industries, most notably textiles. Overall, he concludes that the manufacturing sector did not decline in absolute terms, although there is evidence of a diminishing growth rate during the boom period.

Issa et al. (2006) examine the Dutch Disease in the Canadian economy through one of its symptoms i.e. the effect of oil boom on real exchange rate (between U.S. and Canada). They revisit the relationship between energy prices and the Canadian dollar in the Amano and van Norden (1995) equation, which shows a negative relationship such that higher real energy prices lead to a depreciation of the Canadian dollar. Based on structural break tests, the authors find a break point in the sign of this relationship, which changes from negative to positive in the early 1990s. Then, they discuss that the break in the effect between energy prices and the Canadian dollar is consistent with major changes in energy-related cross-border trade and in Canada's energy policies. In their model, for the long run relationship the real exchange rate is specified as a positive function of the real energy and commodity prices. For the short run relationship, an error correction model, in which the first difference of the real exchange rate is regressed on the lag of the long run deviation as well as the nominal interest rate differential (between U.S. and Canada), is specified.

In a similar study, Bayoumi and Mhleisen (2006) estimate exchange rate equation as a short-term dynamic model that relates the change in the real exchange rate to changes in energy and non-energy commodity prices as well as short-term interest rate differential between the United States and Canada and a long-term error correction mechanism that relates the exchange rate level to net energy (non-energy) commodity exports as a ratio of non-commodity imports. They find that both energy and non-energy commodity prices have an influence on the Canadian dollar.

Oomes and Kalcheva (2007) examine whether economic developments in Russia have been symptomatic of Dutch Disease. The two main symptoms they test for include (1) an appreciation of the real exchange rate; (2) a slowdown in manufacturing growth (de-industrialization). Regarding the first symptom, using a Behavioral Equilibrium Exchange Rate (BEER) model, they estimate the empirical long-run relationship between the real exchange rate and its determinants. They find evidence of stable cointegration relationships between the real exchange rate, the oil price, the productivity differential, government consumption, net international reserves, and the corruption index for the period between January 1995 and December 2005.

They find that a one percent increase in the oil price leads to a 0.50 percent appreciation of the real exchange rate.

In order to test for the other symptom of Dutch Disease (namely a slowdown in manufacturing growth), they use sector-level data to compare growth rates across Russian sectors for output and employment. They estimate the effect of higher oil prices on five non-oil manufacturing sectors (machinery, chemical and petrochemical, forestry and woodworking, light industry, and food), controlling for changes in foreign demand. They also estimate the overall effect on a manufacturing index (excluding oil). They find evidence that Russia also exhibited this symptom of Dutch Disease. In particular, their sectoral data show that the manufacturing sector has grown more slowly than other sectors since 2001 and manufacturing employment growth has fallen. However, they emphasize that it is difficult to conclude that the observed symptoms are indeed the result of Dutch Disease, because they can be explained by other factors as well. For example, deindustrialization has been a natural phenomenon even in the United States and other advanced industrial countries that are not necessarily resource-rich, simply because, as households become richer, demand naturally tends to shift away from goods toward services.

Forsyth and Nicholas (2008) try to examine whether the Kazakh economy has experienced the Dutch Disease as a result of oil price increases from 1996 to 2005. The general result is that non-oil manufacturing was spared the perverse effects of oil price increases despite the appreciation of the nominal and real exchange rate. Their econometric estimations show that this is mainly because the real exchange rate of the non-oil open sector is not linked to the real price of oil, implying that oil price increases do not lead to a real appreciation of this sector's exchange rate.[1] Regarding the nominal exchange rate, the monetary model indicates that the rise in the nominal price of oil and the rise in nominal oil revenues are possibly linked to an appreciation of the nominal exchange rate against the US dollar.[2]

In general, the results of these studies indicate that the Dutch Disease is not a widespread and general phenomenon, although it has been observed in many cases. The low degree of exposing to foreign competition and market power as well as government policies (like subsidies for manufacturing industries) have been introduced as the major reasons for the lack of the

[1] In this model, the real exchange rate, using the PPI excluding oil prices, is regressed on the productivity, the real price of oil or the oil revenues as well as a number of macroeconomic variables such as the public debt-to-GDP ratio, the public expenditure-to-GDP ratio, openness, terms of trade and net foreign assets.

[2] In this model, the nominal exchange rate, based on the monetary approach, is regressed on the relative money supply, the interest differential, the relative income, relative productivity, the price of oil and total oil revenues.

Dutch Disease phenomenon. However, it seems there are two major issues related to these studies. As it can be observed, these studies have considered the aggregate manufacturing sector as the tradable sector (or few sub-sectors in manufacturing sector). However this level of aggregation could lead to biased results because of high cross-industry heterogeneity in terms of market structure.[1] Moreover, they emphasize that it is difficult to conclude that the observed symptoms are indeed the result of Dutch Disease, because they can be explained by other factors (such as the emerging role of China in the world economy) as well that are unobservable or unmeasurable and there is no variable in the model to control for them. In our empirical work we try to address these issues.

So far, we have explained the concept of the Dutch Disease and reviewed some theoretical and empirical studies in this regard. However, we did not provide an analytical framework that demonstrates different aspects of Dutch Disease in detail. It seems this kind of framework would be useful for interpreting the empirical findings and presenting policy implications. Therefore, from the existing literature we choose an analytical framework, which is presented in the next section, to show how Dutch Disease may occur as a result of natural resource booms and examine different aspects of this phenomenon.

1.3 Theory of the Dutch Disease: A Chosen Analytical Framework from the Literature

The objective of this section, which is based on the analysis in Neary (1985) and Neary and Wijnbergen (1986), is to present a theoretical framework to understand how Dutch Disease may occur as a result of natural resource booms. This analytical framework, which has been chosen from the existing literature, has this ability to explain the static and dynamic aspects of the Dutch Disease phenomenon while it is easy to understand. Considering that resource discovery is a real shock, its effects are examined in a real model of open economy which abstracts from monetary consideration.[2] To make the analysis simple, at first, the static effects of a resource boom are examined. In this model, we also examine the consequences of wage and price rigidities on the effects of a resource boom. Then, the dynamic aspects of Dutch Disease, which throw light on the timing of the required real adjustments, are

[1] See Pesaran and Smith (1995).

[2] We focus on the effects of natural resource discoveries, however, most of the analysis applies to the effects of the exogenous increases in the price of naturel resources with only small modifications.

presented. Finally, conclusions are discussed.

1.3.1 The Dutch Disease in a Static Framework

The static effects of Dutch Disease can be analyzed in a model with two sectors. One sector produces a single non-tradable good (services) whose price is determined endogenously by domestic supply and demand. The other sector consists of two tradable subsectors, one which experiences the boom (oil) and the other one which is affected by booming sector (manufacturing). The tradable sector produces a composite traded good that is completely exposed to foreign competition, facing fixed world prices for their outputs.[1] The output levels of the two sectors are denoted by x_n (n for non-tradable) and x_t respectively.[2] Regarding the factor markets, it is assumed that each sector uses a specific factor and also draws on a common pool of inter-sectorally mobile labour.

To understand the channels through which a boom influences the rest of the economy, at first this model assumes that the booming sector does not directly compete with other sectors for factors of production. Under this assumption, the boom would be like an exogenous transfer which affects the domestic economy only through a spending effect. However, this assumption will be relaxed later to be able to examine the resource movement effect in addition to spending effect.

1.3.1.1 The Spending Effects of a Boom

The spending effects can be explained by the market equilibrium condition for the non-traded good which is specified as follows:

$$x_n(q) = c_n(q, y) \tag{1.1}$$

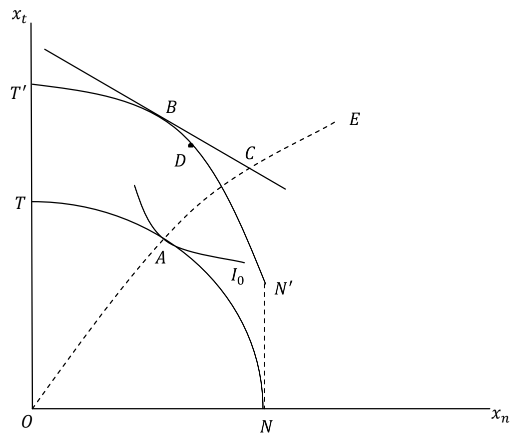
where x_n and c_n are the domestic production and consumption of the non-traded goods respectively. y is the level of real income (measured in terms of the traded goods) which is fixed exogenously by the assumption of full employment and market equilibrium is achieved

[1]Therefore, it is reasonable to assume that the relative price of the two traded goods does not change. This enables an aggregation of the booming tradable and the non-boom tradable goods into a single composite traded good.

[2]Regarding the examples for tradable and non-tradable sectors, it should be emphasized that these examples may be inappropriate in some applications. For example, many medium-sized economies face less than infinitely elastic demand curves for their manufacturing export and therefore the terms of trade (price of exports relative to imports) is influenced by domestic conditions, and so their manufacturing sectors are more like to what we consider the services sector in this paper.

by adjustments of the price of non-traded relative to traded goods q (its inverse is often referred as the real exchange rate). If a boom occurs, y will increase in a once-off fashion and therefore it will lead to excess demand for non-traded goods and so q increases (real appreciation). The implications of the boom for the pattern of output in the economy can be illustrated using the Figure 1.1.

Figure 1.1: The Spending Effect of a Resource Boom



The curve TN is the economy's initial production possibilities frontier, depending on the domestic technology and factor endowments. Point A is the initial equilibrium. Since the boom is equivalent to a transfer, its effect is to shift the production possibilities curve vertically upwards to $T'N'N$ as shown. The initial real exchange rate equals the slope of the common tangent to the two curves at point A. If this were to remain unchanged, the production point would shift vertically upwards to point B: domestic output of both manufactures and non-traded goods remains unchanged but total traded goods increase by the extent of the additional resource output.

With production and therefore domestic real income determined at B, desired consumption must lie along the price line tangential to B. Moreover, since relative prices are unchanged, it must take place at the point C where the price line intersects the income-consumption curve through A, OAE. As a result of the excess demand for non-tradable goods, their relative price will increase until the new equilibrium at a point such as D is attained. At this point, domestic welfare has risen, but at the expense of a reallocation of production—the output of the non-traded good has risen while that of manufacturing has fallen. Thus, the spending effect of the boom unambiguously leads to both deindustrialization and a real appreciation.

1.3.1.2 The Resource Movement Effect of the Boom

Here, it is assumed that the booming sector requires a significant input of productive factor which must be taken from other sectors in the economy. Considering that labour is the only inter-sectorally mobile factor, equation 1.1 should be modified as follows:

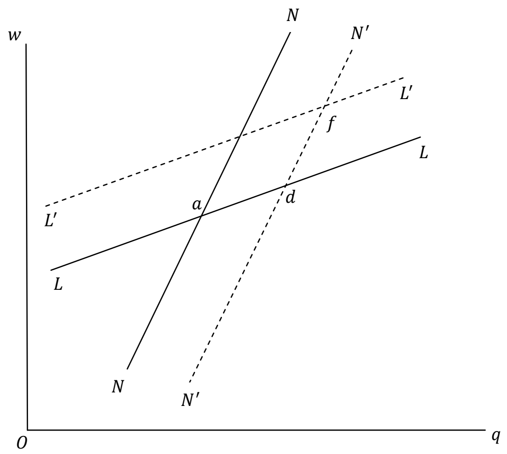
$$x_n(q/w) = c_n(q, y) \tag{1.2}$$

where w is the wage rate, measured in terms of the traded goods. This model has two endogenous variables, q and w, and the additional equilibrium condition is related to labour market:

$$e_n(q/w) + e_m(w) + e_b(w, b) = L \tag{1.3}$$

where L is the total available labour supply, assumed to be fixed, while e_i is the labour demand function from sector i. For the manufacturing and booming sectors, these depend negatively on w, while in the non-traded good sector it depends positively on q/w. Moreover, the boom itself exerts a direct influence on the demand for labour by the booming sector, represented by the inclusion of the parameter b in that sector's labour demand function. The determination of the equilibrium in this model can be illustrated by locating the two equations 1.2 and 1.3 in (w,q) space as illustrated in Figure 1.2.

Figure 1.2: Spending and Resource Movement Effects of a Boom



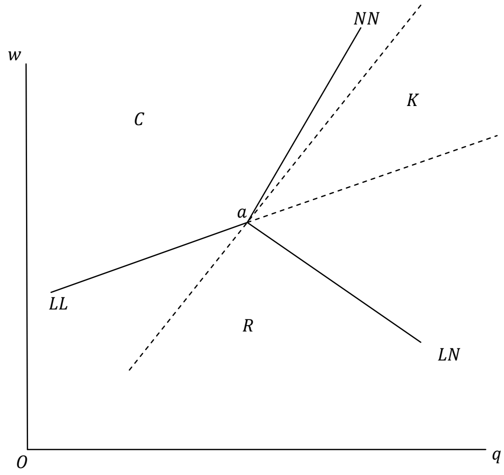
The non-traded goods market equilibrium locus must be upward-sloping, since either an increase in q or a decrease in w induces excess supply of the non-traded good. Given that supply is a function of both q and w, with positive and negative effects, respectively, equal increases in q and w, will leave supply unchanged, but demand will be negatively affected by the increase in q. Therefore, in the (w,q) space, an equi-proportionate increase in w and q will cause excess supply of the non-traded goods. Thus, w must increase by relatively more than the increase in q, for equilibrium to be maintained, i.e the NN locus must have a slope greater than one. Similarly, the labour market equilibrium locus must also be upward-sloping, since either an increase in w or a decrease in q will lead to unemployment. But an equi-proportionate increase in w and q leads to no change in employment in the non-traded goods sector; it leads to a reduction in employment in the (booming and non-booming) tradable sectors (equation 2). Hence, overall excess supply of labour is created. Therefore equilibrium in the labour market requires that q must increase by more than the increase in w; i.e. the LL curve has a slope of less than one. Point a shows the initial equilibrium.

The effects of the resource boom are now easily illustrated. Through the spending effects, excess demand for the non-tradable output is created, and this causes the NN locus to shift to the right, to $N'N'$. If there are no resource movement effects, the increase in wage rates and the real exchange rate appreciation are denoted by the movement from point a to point d, corresponding to point D in Figure 1.1. The effect of the boom in the labour market, however, is such that the demand for labour increases in the booming sector and for equilibrium to be maintained, wage rates have to rise. Thus, the LL locus shifts to the left, to $L'L'$. There is thus a further increase in w and q, from point d to point f in Figure 1.2. The final equilibrium is at point f. This means that the two principal conclusions of the last part are again confirmed: deindustrialization and a real appreciation must follow the boom. But, the implications for the output of the non-tradable sector are ambiguous. This depends directly on the ratio q/w, and it is clear from the diagram that this may rise or fall, depending on which of the two effects dominates.

1.3.1.3 The Effects of Wage and Price Rigidities

So far, it was assumed that the price of the non-traded good is perfectly flexible, so that economy moves instantaneously to the new equilibrium. If the wage and price are rigid, in the short run agents on the long side of either market will be rationed, in the manner familiar from the disequilibrium or fix-price macroeconomic literature. For simplicity, the case where the boom has only a spending effect is considered. To examine the effects of wage and price rigidities, at first, it should be shown how different exogenous values of the wage and the price of the non-traded good lead to different disequilibrium regimes in (w,q) space. This is done in Figure 1.3, where the dash curves represent the notional equilibrium loci from Figure 1.2, while these differ from the effective equilibrium loci (Wijnbergen, 1984b).

Figure 1.3: Disequilibrium Regimes with Wage and Price Rigidities



First, consider the labour market equilibrium locus. Since labour supply is exogenous, the notional locus is unaffected if household are rationed in the non-traded good market. Since the booming sector does not use labour (given the assumption that there is no resource movement effect), equation 1.3 should be modified as follows:

$$e_n(q/w) + e_m(w) = L \tag{1.4}$$

This curve is labelled LL, and extends to the left of point a in Figure 1.3. But, to the right of that point there is excess supply of the non-traded good. Therefore, domestic producers are rationed and thus decrease their labour demand as a result of the sale constraint. Consequently, the labour market equilibrium should be revised as follows:

$$\tilde{e}_n[c_n(q/w)] + e_m(w) = L \tag{1.5}$$

The above equation shows that the employment in the non-traded sector depends negatively rather than positively on q because employment is now demand-determined. Therefore, the locus is downward sloping in (w,q) space, and is denoted by the line LN in Figure 1.3.

Now, consider the equilibrium locus for the non-traded good market. Under excess demand for labour the effective non-traded good market equilibrium locus would be LN curve just derived.[1] With unemployment, the locus is formally identical to equation 1.2, except that the level of income is determined endogenously:

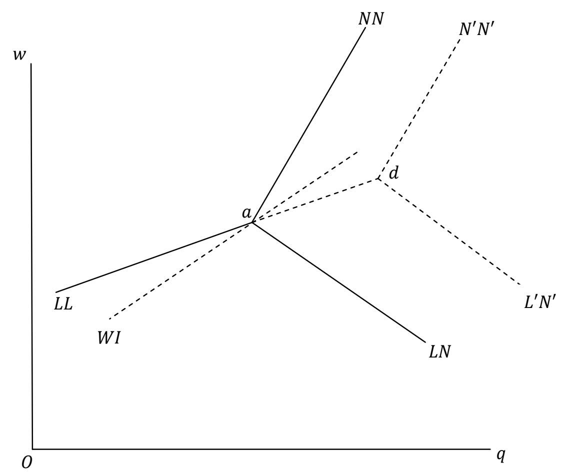
$$y = qx_n(q, w) + x_m(w) + \nu \tag{1.6}$$

[1]For details, see Wijnbergen (1984b).

where ν is the value of the natural resource discovery. This locus is labelled NN in Figure 1.3. It can be shown that it is upward-sloping and more steeply sloped than the corresponding notional locus.

Based on the effective equilibrium loci, the diagram is partitioned into three regions, each related to a different disequilibrium regime. Following Malinvaud (1977), these are labelled C for classical unemployment, K for Keynesian unemployment and R for repressed inflation. The next step is to investigate the effects of the resource discovery on the loci. Since the resource movement effect has been excluded, it is clear from equation 1.4 that the LL locus is not affected. However, the same is not true for the NN and LN loci. The spending effect of the boom leads to a greater demand for non-traded good and, as it has been shown in Figure 1.4, the Walrasian equilibrium shifts to point d. This is the same as point d in Figure 1.2. However, the new feature is that the economy does not immediately jump to d, but instead remains at the short run at point a. Therefore, the initial effect of the resource boom is to leave the labour market in equilibrium and to induce excess demand for the non-traded good.

Figure 1.4: Effects of a Boom with Wage and Price Rigidities



The main question is that how the economy will move from a to d and, in particular, whether any unemployment will emerge during the adjustment period. Without specifying the dynamics of adjustment in detail, it may be concluded that the price of the non-traded good will rise as a result of excess demand. However, the behaviour of the wage rate is more complex and depends on the wage indexation rule which is adopted. Following Wijnbergen (1984b), the standard augmented Philips curve assumption that real consumption wages can only be reduced by temporary unemployment is considered. Therefore, the main point is whether the real consumption wage at d is higher or lower than it is at a.

To answer this question, the wage indexation locus, labelled WI, is added to the figure.

To derive the WI locus, it is assumed that the real consumption wage may be identified with the utility level of wage earners and their expenditure function:

$$w = E(p, q, u) \tag{1.7}$$

where p is the price of the traded goods which is fixed. The equation 1.7 for the initial level of utility defines the WI locus. It can be shown that there is a positive relationship between the share of the non-traded good in the consumption basket of wage-earners and the slope of the WI locus. Figure 1.4 shows the case that the WI locus is more steeply sloped than the LL locus so that the movement from a to d requires a fall in the real consumption wage and transitional unemployment must result. As Wijnbergen (1984b) showed, this result requires that the non-traded sector be more important in demand than supply, in the sense that the share of its output in the consumption of wage-earners must exceed its contribution to a weighted average of the supply elasticities of the two sectors. Conversely, if the non-traded good sector is less important in demand than in supply in this sense, the boom will raise the real consumption wage over time, and the economy enters a period of generalized labour shortage as it moves into the R region.

These results are consistent with some of the stylized facts of how different countries have responded to natural resource discoveries and increase in the prices of resources. Thus, the countries of Persian Gulf, many of which import virtually all their consumption goods, experienced excess demand for labour after the oil price shocks. On the other hand, Latin American oil producers, with a long history of prohibitive tariff barriers making many of their consumer goods virtually non-traded, saw no employment benefits and in some cases (Mexico and Venezuela) increases in unemployment after the oil boom. Finally, it is emphasized that the addition of a resource movement effect makes it more likely that labour shortage rather than unemployment will emerge, since, as already shown in Figure 1.2, this provides a boost to the wage rate additional to that induced by the spending effect.

1.3.2 Deindustrialization and Dynamic Adjustment

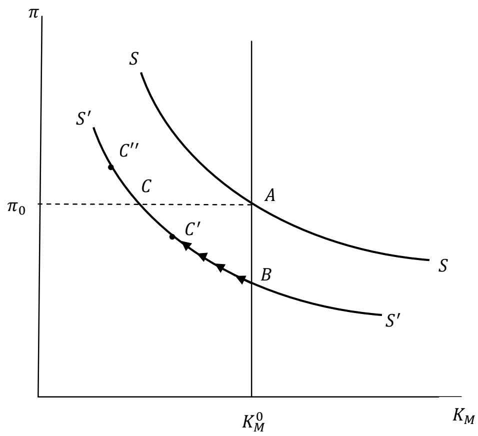
In the provided static model, a real appreciation was one of the channels of deindustrialization. However, these two phenomena are not necessarily associated. Here, a different model is presented in which deindustrialization is inevitable, but there may be a real depreciation in the long run. This model also introduces an explicit temporal sequence of effects in the static model. Thus, this model is able to consider dynamic issues such as the influence of expectations on the time path taken by the economy. This model, which is based on Neary and Purvis (1981), has the same sectoral structure as that of the static model but the specification of factor markets is different. In particular, it is assumed that the booming sector does not use the mobile factors in the short run, thus excluding any resource movement effect over that time horizon. However, both the booming and manufacturing sectors use stocks of capital, which can be gradually augmented or depleted with the passage of time. Manufacturing can also draw on a pool of labour, which is instantaneously mobile between that sector and the non-traded goods sector. Finally, it is assumed that both booming sector and the non-traded goods sector use a permanently specific factor.

Assuming that the economy is initially in long run equilibrium, the effects of the boom in this model are illustrated in Figure 1.5. The horizontal axis shows the stock of capital located in manufacturing sector. Thus, in the short run, the economy is constrained by the initial allocation of capital to that sector, K_M^0. The vertical axis shows the real exchange rate π, which is the inverse of q, the relative price of the non-traded goods. The curve SS indicates the combinations of π and K_M which create equilibrium in the market for non-traded good before the boom.[1] Considering that in the short run the boom has only a spending effect in this model, the market equilibrium locus will shift from SS to $S'S'$ as a result of the boom. Following the increased demand for the non-traded good, either a fall in π or contraction of the manufacturing sector (so releasing labour to non-traded sector) is required to maintain the equilibrium. With K_M fixed in the short run, the new short run equilibrium would be at point B implying a real appreciation which induces a rise in wage relative to the price of manufacturers so that manufacturing output and employment contract.

However, this real appreciation disturbs the initial capital-market equilibrium, by reducing the return to capital in the manufacturing sector. Since the return to capital in the booming sector has risen in any case as a direct consequence of the boom, there is now a clear incentive to decrease the stock of the capital in manufacturing. Whether this is done by reallocating existing capital goods or by allowing them to depreciate without replacing them, the results for the medium-run adjustments of the economy are the same: the real exchange rate gradually rises as the equilibrium point moves in a north-westerly direction along $S'S'$, as indicated by the arrows in the diagram. Consequently, the demand for the non-traded

[1] This curve is downward-sloping, since a rise in K_M leads to movement of labour from non-traded goods sector and so creates excess demand. Therefore, π must decrease which both stimulates the supply of and discourage the demand for the non-traded good.

Figure 1.5: Deindustrialization and Dynamic Adjustment



good rises, both because its relative price falls and because capital is being allocated more efficiently between sectors, which raises real income. Hence, the equilibrium output of the non-traded good must rise, which leads to labour movement from the manufacturing sector. Since manufacturing is simultaneously losing capital, the sector's output must fall steadily as the economy moves away from point B.

If capital is available from abroad at a fixed world rental, the long run equilibrium real exchange rate is unaffected by the boom and so the economy converges to point C. Alternatively, if capital is a non-traded factor available in fixed supply, the final equilibrium may be at points such as C' or C''.[1] Under each of these assumptions about the capital market, the implications for the Dutch Disease symptoms are the same: both the initial real appreciation and the subsequent real depreciation are associated with steady declines in manufacturing output and employment.

This dynamic model also allows us to consider the role of expectations. This model clearly shows that what is important is not the date at which boom occurs, but the date at which the consequences of this are foreseen by different agents in the economy. If consumers anticipate an increase in real national income, their capitalized permanent income is increased so that their current demand for non-traded good rises. Similarly, given positive adjustment costs, factor owners will begin to reallocate capital out of manufacturing and into the expected booming sector. Therefore, both the spending and the resource movement effect of the boom may lead to contraction of the output of manufacturing before any boom takes place.

[1]For details, see Neary and Purvis (1981).

1.3.3 Conclusions of the Theoretical Framework

In this section, the effects of natural resource boom were examined in the static and dynamic theoretical models. Here, the implications of these models for some of the practical policy questions related to this issue are summarized.

Is Deindustrialization Inevitable?

Deindustrialization, in the sense of a decline in output and employment in the exposed manufacturing sector, is exhibited by both static and dynamic models. However, there is an important point that should be considered. The main features of the sectors that may be expected to decline are that they are exposed to foreign competition and have little or no ability to set their own prices. Thus, export-oriented agricultural or even service sectors may be squeezed; and, conversely industries that cater for the home market as a result of trade protection or that possess monopolistic price-setting powers in their export markets may benefit from the rise in home demand. Moreover, it should be emphasized that deindustrialization is in general a symptom of the economy's adjustment to its new equilibrium and it is not necessarily a disease that requires corrective action.

Is a Real Appreciation Inevitable?

The provided models were different in predicting whether a resource boom will leat to real appreciation (increase in the price of the non-trade relative to traded goods) or not. While the static model predicts that the real appreciation is inevitable, the dynamic model implies that the real exchange rate could remain unchanged after the boom if capital is available from abroad at a fixed world rental.

Can a Resource Boom Generate Unemployment?

Based on the provided model, if the weight of non-traded goods in the consumption basket of wage earners is sufficiently large, then real wage rigidities can lead to transitional unemployment following a resource boom.

1.4 Empirical Framework

As the theoretical framework shows, the Dutch Disease happens mostly through changes in the real exchange rate as a result of the resource boom. Therefore, in our empirical work, we will first estimate the relationship between real exchange rate and energy prices using an error correction model. We then examine the effect of real exchange rate on output of the manufacturing industries. Based on these two estimations, we can calculate the Dutch Disease effect (the effect of energy prices on output of the manufacturing industries).

1.4.1 The Real Exchange Rate Equation: An Error Correction Model

The oil shocks of the 1970s stimulated numerous research papers on how commodity price shocks would affect real exchange rates in small open economies, including the implications of the Dutch Disease for commodity producers.[1] This line of enquiry also led a number of researchers to try to use world commodity price shocks to explain the exchange rate movements of commodity producers, such as Australia (Blunndell-Wignall and Gregory, 1989; Gruen and Wilkinson, 1994), Canada (Issa et al., 2006; Bayoumi and Mhleisen, 2006), and Norway (Akram, 2004).

The purpose of this section is to estimate the relationship between real exchange rate and energy prices in Canada over the time period 1992-2007. Although the basic structure of presented model is based on Bayoumi and Mhleisen (2006) and Issa et al. (2006), we try to control for other determinants (such as productivity and net foreign assets) emphasized in the literature (Lane and Milesi-Ferretti (2004), Oomes and Kalcheva (2007), Egert and Leonard (2008)) but ignored in the Canadian studies. Moreover, we test whether the effect of energy prices on the Canadian dollar has changed over time as it has been applied by Issa et al. (2006).

Based on Bayoumi and Mhleisen (2006) and Issa et al. (2006), we specify the long run relationship between the real exchange rate and its determinants as follows:

$$log(re_t) = c_l + \theta_{en}\, log(stben_t \times p_t^{en}) + \theta_{oc}\, log(stboc_t \times p_t^{oc}) + \varepsilon_t \tag{1.8}$$

where re_t is the real exchange rate between U.S. and Canada, p^{en} is the energy price index deflated by US implicit price index, p^{oc} is the other commodities price index deflated by US implicit price index. $stben_t$ and $stboc_t$ show respectively the energy and other commodities trade balance as a ratio of the total commodities trade balance. These variables are included to capture the relative importance of shocks in energy and other commodity prices for exchange rate adjustment. c_l and ε_t are the intercept and the error term, respectively.

[1]See the studies provided in literature review.

After finding the cointegration relationship between the variables included in equation 1.8, the short run relationship is estimated using an error correction model as below:

$$
\begin{aligned}
\triangle log(re_t) = c_s + \varphi_{en} \triangle log(stben_t \times p_t^{en}) + \varphi_{oc} \triangle log(stboc_t \times p_t^{oc}) + \alpha_i \, idiff_{t-1} \\
- \rho(log(re_{t-1}) - c_l - \theta_{en} \, log(stben_{t-1} \times p_{t-1}^{en}) - \theta_{oc} \, log(stboc_{t-1} \times p_{t-1}^{oc})) \\
+ \sum_{i=1}^{n} \chi_i \triangle log(re_{t-i}) + \nu_t
\end{aligned}
\tag{1.9}
$$

where $idiff$ is the short-term interest rate differential between the U.S. and Canada which is expected to affect the short run adjustments of the real exchange rate. This variable was lagged to avoid simultaneity bias.[1] ρ describes the speed of adjustment back to long-run equilibrium. χ_i shows the coefficient of the ith lag of the dependent variable. Considering that different factors may show their impact on real exchange rate during the time, the lags of the dependent variable are also included in the model. c_s and ν_t are the intercept and the error term and $\triangle$ denotes the changes in each specific variable.

Equation 1.9 differs from the earlier studies of the Canadian real exchange rate in Bank of Canada (Helliwell et al., 2005; Issa et al., 2006) in the sense that it specifies a more general form of an error correction model. Specifically, it relates the short-term rate of change in the exchange rate to the contemporaneous rate of change of commodity prices, rather than only through the error correction mechanism. However, as literature shows, there are some other determinants that should be included in the model. As emphasized by Oomes and Kalcheva (2007), and Egert and Leonard (2008), the productivity differential should be included in the long run equation. Their justification for entering this variable in the model is based on the Harrod-Balassa-Samuelson hypothesis: productivity shocks, that increase permanently domestic labor productivity in manufacturing (the measure of tradables) relative to an aggregate of trading partners, raise relative consumption, lower net exports, and raise the relative price of non-tradables.

Net foreign assets is another variable that is included in the short run real exchange rate equation (Obstfeld and Rogoff, 1995,1996; Lane and Milesi-Ferretti, 2004). Obstfeld and Rogoff (1996) explain how wealth transfer between countries affects the real exchange rate using a Ricardian model where a range of goods is not traded, due to transport costs. In

[1]Considering that p_t^{en} and p_t^{oc} are determined in the world market and are exogenous for the Canadian economy, there is no concern regarding the simultaneity bias for these variables.

this setting, a transfer from the foreign country to the home , which is in fact a decrease in net foreign assets[1], increases domestic wealth and thus spending on home non-tradables: home wages increase, the home export sector declines, and the foreign export sector expands. Thus, the real exchange rate appreciates due to increase in the price of non-tradables as a result of higher wages.

After including the measures for productivity differential and net foreign assets in the long and short run equations respectively, the equations 1.8 (the cointegration relationship) and 1.9 (the error correction model) can be modified as follows:

$$log(re_t) = c_l + \theta_{en}\, log(stben_t \times p_t^{en}) + \theta_{oc}\, log(stboc_t \times p_t^{oc}) + \theta_{prodiff}\, prodiff_t + \varepsilon_t' \qquad (1.10)$$

where $prodiff$ is the productivity differential defined as the difference in labour productivity growth between Canada and US.

$$\begin{aligned} \triangle log(re_t) = {} & c_s + \varphi_{en} \triangle log(stben_t \times p_t^{en}) + \varphi_{oc} \triangle log(stboc_t \times p_t^{oc}) + \varphi_{NFA} \triangle NFA_{t-1} \\ & + \alpha_i\, idiff_{t-1} - \rho(log(re_{t-1}) - c_l - \theta_{en}\, log(stben_{t-1} \times p_{t-1}^{en}) - \theta_{oc}\, log(stboc_{t-1} \times p_{t-1}^{oc}) \\ & - \theta_{prodiff}\, prodiff_{t-1}) + \sum_{i=1}^{n} \chi_i \triangle log(re_{t-i}) + \nu_t' \end{aligned} \qquad (1.11)$$

where NFA is the net foreign assets of Canada.[2] The equations 1.10 and 1.11 are the base for our empirical estimations presented below.[3]

1.4.1.1 Estimation Results

Before estimating the equation 1.10, looking at Figure 1.6 for real exchange rate data clearly shows a change in its pattern after the second quarter of 2002. While the real exchange rate is increasing (depreciation of the domestic currency) till the first quarter of 2002, it starts to decrease (appreciation of the domestic currency) from the second quarter of 2002 to the end

[1]The difference between total international financial assets and total international financial liabilities is referred to as the net foreign asset position. For example in the case of Canada, Canadian international financial assets are owned by Canadian residents and embody future economic benefits from non-residents. Canadian international financial liabilities are owned by non-residents and embody future economic benefits from Canadian residents. Therefore, a transfer from the foreign country to the home is in fact a decrease in net foreign assets. See Lane and Milesi-Ferretti (2004)) and Table 376-0055 of CANSIM for the details of the composition and calculation of the net foreign assets.

[2]This variable was lagged to avoid simultaneity bias.

[3]See Appendix B for construction and the sources of data.

of the period of study. On the other hand, energy prices increase sharply from the second quarter of 2002 and reach to the levels that had not been experienced before. The same pattern, to a lesser extent, is observed for the price of other commodities (see Figures 1.7 and 1.8). These facts suggest that, in our sample, the relationship between real energy and other commodities prices and the real Canadian dollar might have changed around the second quarter of 2002.

Figure 1.6: Real Exchange Rate

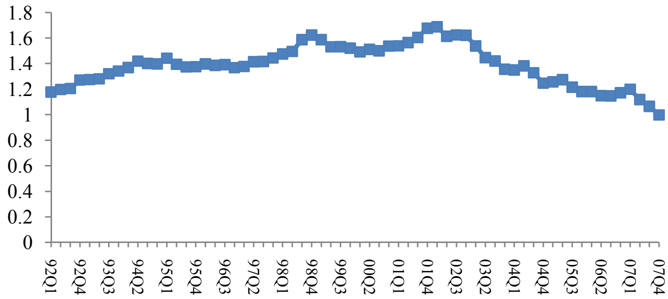


Figure 1.7: Real Energy Price Index (82-90=100)

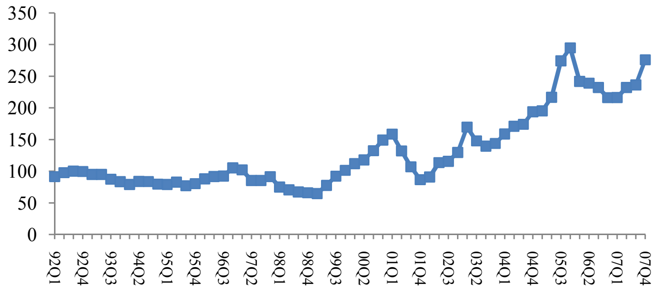
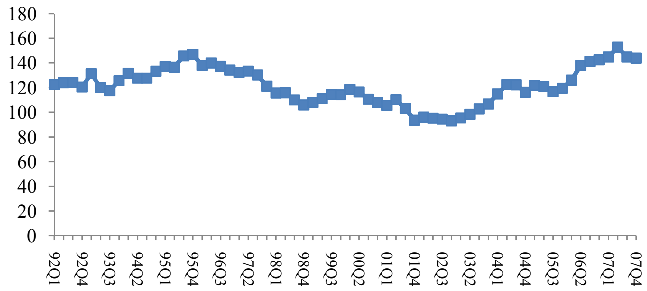


Figure 1.8: Real Other Commodity Price Index (82-90=100)



The Zivot-Andrews unit root test, which allows for one structural break in the intercept, trend or both as well as the ADF unit root test reveal that all variables included in the long-run equation contain unit roots except for productivity differential (see Tables A.1 and A.2 in Appendix A).[1] This implies that the conventional tests to detect structural break, such as Chow or Quandt-Andrews tests would not be appropriate. To find the breakpoint, we employ the Gregory and Hansen's (1996) cointegration test which allows for a single break of unknown timing in the intercept and/or slope coefficients. This test, which has been explained in Appendix A, shows the last quarter of 2003 as the breakpoint. Therefore, a dummy variable *dum* (1 for observations before 2003q4 and 0 for other observations) is added to the intercept and slope coefficients to capture the structural change in the effects of real energy and other commodities prices on the real Canadian exchange rate. After adding three terms (dum, $dum \times log(stben_t \times p_t^{en})$ and $dum \times log(stboc_t \times p_t^{oc})$) to equation 1.10, we can estimate the long run relationship while control for the structural change as follows:

$$\begin{aligned} log(re_t) = c_l + dum + \theta_{en}\, log(stben_t \times p_t^{en}) + \theta_{endum}\, (dum \times log(stben_t \times p_t^{en})) + \\ \theta_{oc}\, log(stboc_t \times p_t^{oc}) + \theta_{ocdum}\, (dum \times log(stboc_t \times p_t^{oc})) + \theta_{prodiff}\, prodiff_t + \varepsilon_t'' \end{aligned} \tag{1.12}$$

The estimation results of equation 1.12, using quarterly data during 1992q1-2007q4, are reported in Table 1.1.[2]

Table 1.1: Real Exchange Rate Equation: Long Run Relationship

Variable	Estimates	t-Statistic
log(Real Energy Prices × $stben_t$**)**	-0.54	-7.04
Dum× (log(Real Energy Prices × $stben_t$**))**	0.39	4.49
log(Real Other Commodity Prices× $stboc_t$**)**	-0.73	-6.07
Dum× (log(Real Other Commodity Prices × $stboc_t$**))**	0.58	3.36
Productivity Differential	-2.68	-2.17
R-squared	0.86	
Number of observations	64	

Note: All Coefficients are interpreted as percentage.

[1] After seasonally adjusting the variables that show seasonal pattern (using the seasonal dummies), the unit root tests are conducted for each variable. The Zivot-Andrews is specified such that allows for one structural break in both intercept and trend. In this test, various criteria for detecting the structural break are supported. The ADF test is specified with trend and intercept. Moreover, in both tests, the lag length is chosen based on AIC.

[2] In estimation of the model, we should note that:(a) Seasonal dummies are included to model the seasonality. (b) For finding the cointegration relationships, we use the residuals of equation 1.12 after including trend and seasonal dummies, but for finding the long-run coefficients and residuals we use dynamic OLS (recommended by Stock and Watson, 1993) in which we also include the leads and lags of the first difference of the right hand side variables into the equation.

Based on the Gregory and Hansen's (1996) cointegration test, the critical values to reject the null hypothesis of unit root in residuals are -5.97, -5.50, and -5.23 at 1%, 5%, and 10% significance levels respectively. Considering that the ADF from equation 1.12 is -4.20[1], we fail to reject the hypothesis of unit root in residuals at conventional levels. Then, we follow a bootstrap procedure to find more accurate critical values and p-value that indicates to what extend the test results are in favour of cointegration.[2] The bootstrapped critical values at 1%, 5%, and 10% significance levels are -5.83, -5.18, and -4.82 respectively and p-value is 0.294. This means that the probability of cointegration is 70 percent. This implies that the test results are highly in favour of cointegration, although the level of significance is outside the range of standard practice. Thus, it is reasonable to conclude that the variables are cointegrated.[3] Consequently, in addition to estimating the cointegration relationship as the long-run one, we can estimate an error correction model (ECM), which has the ability to capture the short-term dynamics, as follows:

$$\begin{aligned} \triangle\, log(re_t) = {} & c_s + \varphi_{en} \triangle log(p_t^{en} \times stben_t) + \varphi_{oc} \triangle log(p_t^{oc} \times stboc_t) + \varphi_{NFA} \triangle NFA_{t-1} \\ & + \alpha_i\, idiff_{t-1} - \rho\, \hat{\varepsilon''}_{t-1} + \sum_{i=1}^{n} \chi_i \triangle log(re_{t-i}) + \nu_t'' \end{aligned} \tag{1.13}$$

where $\hat{\varepsilon''}_{t-1}$ is the deviation from the long-run relationship found in equation 1.12. The estimation results of equation 1.13, using quarterly data during 1992q1-2007q4, are reported in Table 1.2.

The long run estimation results suggest that the energy and other commodities prices both play an important role in explaining the real exchange rate trends (see Table 1.1). As it can be observed, energy and other commodities prices have the expected sign and are significant at the 5 percent significance level or better. The productivity differential has also the correct sign and is statistically significant. One percentage point increase in the productivity differential will result in appreciation of the Canadian dollar by 2.68 percent. The results clearly show that the relationship between energy and other commodities prices

[1]Here the unit root test is specified without intercept and trend. Moreover, the lag length is determined based on AIC.

[2]See the structure of the program in Appendix F of the Exchange Rate Pass-Through Chapter.

[3]We have also reported the results of the first difference model for the case that the reader is not convinced that the variables are cointegrated because the level of significance is outside the range of standard practice (see Table A.3 in Appendix A).

Table 1.2: Real Exchange Rate Equation: Error Correction Model

Variable	Estimates	t-Statistic
$\triangle$ (log(Real Energy Prices$\times$ *stben*))	-0.11	-4.65
$\triangle$ (log(Real Other Commodity Prices $\times$ *stboc*))	-0.17	-3.66
$\triangle$ Interest Rate Differential	-1.1	-2.37
$\triangle$ Net Foreign Assets	0.07	3.10
Speed of Adjustment	0.18	2.68
$\triangle$ First Lag of Dep. Var.	0.48	4.00
$\triangle$ Second Lag of Dep. Var.	-0.10	-0.86
$\triangle$ Third Lag of Dep. Var.	0.26	2.42
R-squared	0.55	
Number of observations	61	

Note: All Coefficients are interpreted as percentage.

and the Canadian real exchange rate has changed after the fourth quarter of 2003. In the time period between 1992 and the third quarter of 2003, one percent increase in energy prices led to appreciation of the Canadian real exchange rate by 0.15 percent, keeping other things constant. However, this effect increased to 0.54 percent for the time period between the fourth quarter of 2003 and the forth quarter of 2007. On the other hand, the effect of one percent increase in other commodities prices on the real exchange rate was -0.15 percent for the first period while it increased to -0.73 percent in the next period. These changes in the impacts of energy and other commodity prices on the real exchange rate are likely due to sharp increases in energy and other commodities prices that had not been experienced before as well as the development of energy sector due to increases in energy prices.[1]

In the error correction model (see Table 1.2), all variables are correctly signed and significant at the 5 percent significance level or better. Based on these results, one percent increase in energy prices leads to contemporaneous appreciation of the Canadian real exchange rate by 0.11 percent and it increases to 0.30 after three quarters ($0.30 = \frac{0.11}{1-0.64}$ where 0.64 is the summation of the lags of dependent variable). On the other hand, one percent increase in other commodities prices leads to contemporaneous appreciation of the Canadian real exchange rate by 0.17 percent and it increases to 0.47 percent after three quarters. At 0.18, the coefficient on the error correction mechanism implies that it takes about three quarters to reduce a deviation from the long-term trend by 50 percent.

[1]After increase in the oil prices from the second quarter of 2002, total oil production has increased by nearly 25 per cent from 129 million cubic meters in 2002 to around 161 million cubic meters in 2007 (see Tables 126-0001 of CANSIM).

After finding the relationship between real exchange rate and energy prices, in the next section, we examine the effect of real exchange rate on output of the manufacturing industries. Then, based on these two estimations, we can calculate the Dutch Disease effect for each industry.

1.4.2 Sectoral Output Equation

To demonstrate the manner and extent to which the macro-economic environment has influenced Canadian industries growth, in this section, we estimate the equations linking sectoral output to factors affecting relative profitability including real exchange rate. The output equations will be estimated using quarterly data during 1992-2007 for the Canadian manufacturing industries at 3, 4 and few cases of 5 digit levels of North America Industry Classification System (NAICS). The results of these equations along with those from real exchange rate equation will help us to assess whether Canadian industries have experienced Dutch Disease during 1992-2007 as a result of an oil price boom.

In specifying each equation, based mostly on Looney (1990), we assume that the output of each industry is a function of expected profitability of that sector which, in turn, is a function of several factors including real exchange rate, the expected relative rate of inflation (an industry rate of inflation relative to that experienced by the total economy)[1], the expected level of government expenditures as a measure for domestic fiscal policy, the expected level of interest rate as a measure for monetary policy, and the expected level of non-energy GDP as a measure for changes in total demand.[2]

The coefficient of the real exchange rate is directly related to the Dutch Disease effect. By defining the real exchange rate so that a rise in it is a rise in the relative price of manufactured goods, we expect that the sign of this variable (which, in fact, is the price of tradables to non-tradables) for manufacturing industries as the tradables to be positive. However it should be noted that this expectation is based on this assumption that these industries are exposed to foreign competition and have little or no ability to set their own prices. The industries that cater for the home market as a result of trade protection or that possess monopolistic

[1]To estimate the expected industry inflation rate, at first we forecast the producer price index in each industry in $t + 1$ using a regression in which the producer price index in each industry is regressed on its value for the previous quarter as well as the intercept, trend and seasonal dummies. Then, using the values of price index in t and $t + 1$, we calculate the the expected industry inflation rate. The same method was used to compute the expected rate of inflation for total economy.

[2]The expected levels of government expenditure, interest rate and non-energy GDP are the fitted values resulted from regressing each variable on its value for the previous quarter as well as the intercept, trend and seasonal dummies.

price-setting powers in their markets may benefit from the rise in home demand as a result of oil boom and therefore the sign of the real exchange rate for these industries would be negative. In general, there is justification for both positive and negative signs but positive coefficient indicates that the industry is suffering from the Dutch Disease.

The expected relative inflation rate is intended to capture the net short run impact on profitability resulted from changes in the cost of imported inputs associated to exchange rate movements together with the ability of firms to pass these costs on in the form of higher prices. The increase in the expected relative inflation rate would increase the profitability of each industry and therefore its sign should be positive. Regarding the effect of government expenditures, since we just have access to over-all level of government expenditures, the sign of this variable is not clear in advance. Considering that the government expenditures are financed by collected taxes from all sectors of the economy and are spent for specific purposes (construction machinery, transportation and medical equipments,...), the sign of government expenditures could be positive or negative depending on whether the industry share in government expenditures is greater than the share in paid taxes. The sign of variable related to monetary policy (interest rate) should be negative because decrease in interest rate encourages the investment. It is expected that the sign of non-energy GDP to be positive as it captures the effect of increase in demand.

In estimation of Dutch Disease effects, there are some difficulties which have been ignored in the previous studies and we will try to address them. First and the most important point is related to the level of aggregation for tradable sector. The previous studies have usually considered two sub-sectors in tradable sector: manufacturing and agriculture, however this level of aggregation will lead to biased results. As it was explained before, the Dutch Disease effect is very sensitive to the structure of the industry including whether the industry is exposed to foreign competition or is catering for the home market as a result of trade protection, the role of changes in the cost of imported inputs associated to exchange rate movements and the ability of industry to pass these costs on in the form of higher prices. As Pesaran and Smith (1995) have emphasized, in an environment where cross-sectional heterogeneity is significant, the use of aggregate data may lead to heavily biased estimates . Therefore, it would be more appropriate to examine the Dutch Disease effect using disaggregated data. To incorporate this issue, the output equations for the Canadian manufacturing industries are estimated at 3, 4 and few cases of 5 digit levels of North America Industry Classification System—NAICS—(about 80 industries).

Second, to have a robust estimate of the Dutch Disease effect (contraction of tradable industries due to appreciation of real exchange rate as a result of an oil boom), it is clear that one should control for all other determinants of output in tradable industries. Although some studies have incorporated some factors including domestic monetary and fiscal policy, exogenous domestic supply shocks and international commodity price changes, there are some unobservable or unmeasured factors affecting industrial reallocation in developed countries. For example, deindustrialization has been a natural phenomenon even in the United States and other advanced industrial countries that are not necessarily resource-rich, simply because, as households become richer, demand naturally tends to shift away from goods toward services. The other related factor is the emerging role of China in the world economy (see Macdonald, 2007). To control for these unmeasured factors, we will use the U.S. as a control country (which is not an oil exporting country) and the output of each specific industry for this country will be considered as an explanatory variable which is expected to affect positively the output of each sector. By entering this variable to the output equation, we, in fact, control for all (measurable and unmeasurable) factors affecting the industrial production in industrial countries in general. Therefore, we can conclude that the observed symptoms (significant positive coefficients for real exchange rate) are indeed the evidence of Dutch Disease.

Based on the above theoretical considerations, we can specify the output equation as follows[1]:

$$\begin{aligned} log(Y_{k,t}^{CAN}) &= \alpha_k + \beta_{1,k}\, log(Y_{k,t}^{U.S.}) + \beta_{2,k}\, RINFR_{k,t}^{CAN} + \beta_{3,k}\, log(GDP_t^{CAN}) + \beta_{4,k}\, log(re_t) \\ &+ \beta_{5,k}\, log(GOVEX_t^{CAN}) + \beta_{6,k}\, log(INTR_t^{CAN}) + \sum_{i=1}^{n} \lambda_{i,k}\, log(Y_{k,t-i}^{CAN}) + \epsilon_{k,t} \end{aligned} \tag{1.14}$$

where $Y_{k,t}^{CAN}$ is the Canadian production in industry k, $Y_{k,t}^{U.S.}$ represents the U.S. production in industry k, $RINFR_{k,t}^{CAN}$ shows the Canadian expected relative inflation rate in industry k[2], GDP_t^{CAN} is the non-energy gross domestic product in Canada, re_t shows the real exchange rate, $GOVEX_t^{CAN}$ is the Canadian government expenditure, $INTR_t^{CAN}$ denotes Canadian

[1]Because of difficulties in adjusting the level of output, it is expected that the real exchange rate shows its impact on output during the time. Therefore, the lags of the dependent variable are also included in the model and the lag length is determined base on the AIC.

[2]Industry k rate of inflation relative to that experienced by the total economy.

interest rate, and α_k and $\epsilon_{k,t}$ are constant and disturbance term for industry k, respectively. Based on the theoretical considerations, it is expected that the sign of interest rate coefficient to be negative, while there is no prior expectation regarding the signs of the real exchange rate and the government expenditures. The signs of all other variables are expected to be positive. In this specification, $\beta_{4,k}$ helps us to determine whether industry k has experienced Dutch Disease.

As we know, if the variables are not stationary in levels, the usual inference method would not be valid if this is ignored. An Augmented Dickey-Fuller (ADF) test for unit roots revealed that, except for relative inflation rate and few exceptions for other variables, the variables included in the above equation contain unit roots (see Table A.4 in Appendix A).[1] A test was then used to determine whether the variables (in an equation with intercept and trend) are co-integrated or not based on the unit root in residuals using ADF criteria.[2] However, as Maddala and Kim (1998) pointed out (see Chapter 6 of their book), the critical values are not same as before because we are applying the tests to the estimated residuals instead of the actual residuals. Therefore, the MacKinnon (1991) approximation formula was used for computing the critical values (see Maddala and Kim (1998), Chapter 6, Pages 199-201). According to the calculated critical values for our sample based on this formula[3], except for few cases which can be found in the reported results in Table A.4, we fail to reject the null hypothesis of unit root in residuals.

Then, we follow a bootstrap procedure to find more accurate critical values and p-values that indicate to what extend the test results are in favour of cointegration.[4] As the reported results in Table A.4 indicate, the p-values are between 1% and 10% for 25 industries, between 10% and 20% for 24 industries, between 20% and 30% for 19 industries, between 30% and 40% for 9 industries and more than 40% just for three industries.[5] These results imply that, for most of the industries, the test results are highly in favour of cointegration, although the level of significance is outside the range of standard practice. Thus, it is reasonable to conclude that the variables are cointegrated, except for three industries that their p-values are greater than 40%. Consequently, we are able to estimate the long-run relationships as

[1]Considering that variables are likely trending (like non-oil GDP, sectoral output, government expenditures), the unit root test is specified with intercept and trend. Moreover, the lag length is chosen based on AIC.

[2]Here the unit root test is specified without intercept and trend. Moreover, the lag length is determined based on AIC.

[3]The critical values at 10, 5, and 1 percent significance levels are -4.98, -5.34, -6.06 respectively.

[4]See the structure of the program in Appendix F of the Exchange Rate Pass-Through Chapter.

[5]These three industries are 311, 3211 and 326.

the ones we are specially interested in.[1] Moreover, we can estimate an error correction model (ECM), which has the ability to capture the short-term dynamics, as follows[2]:

$$\Delta log(Y_{k,t}^{CAN}) = \alpha'_k + \beta'_{1,k}\Delta log(Y_{k,t}^{U.S.}) + \beta'_{2,k}\Delta RINFR_{k,t}^{CAN} + \beta'_{3,k}\Delta log(GDP_t^{CAN}) + \beta'_{4,k}\Delta log(re_t)$$
$$+ \beta'_{5,k}\Delta log(GOVEX_t) + \beta'_{6,k}\Delta log(INTR_t) + \sum_{i=1}^{n}\lambda'_{i,k}\Delta log(Y_{k,t-i}^{CAN}) - \rho_k\hat{\epsilon}_{k,t-1} + \epsilon'_{k,t} \tag{1.15}$$

Where Δ shows the first difference, ρ_k describes the speed of adjustment back to long-run equilibrium in industry k and it is expected to be positive. $\hat{\epsilon}_{k,t-1}$ indicates the equilibrium error in $t-1$ obtained from the co-integration relationship.

Equation 1.14 as well as the short-run relationship (equation 1.15), are estimated[3] for 3 and 4 digit (and few cases for 5 digit) NAICS industries which their comparable data in the U.S. and Canada are available (about 80 industries) using quarterly data from the first quarter of 1992 to the second quarter of 2007. The U.S. Bureau of Labor Statistics (BLS) provides the data for the sectoral output levels in the U.S., while the Canadian data have been obtained from the CANSIM.[4]

1.4.2.1 Estimation Results

Estimation results of equation 1.14, as the long run relationships, are reported in Table 1.3. Before focusing on the estimates of the elasticity of real exchange rate with respect to output as the variable we are interested in, it is useful to examine the estimates of the other variables. With few exceptions, the estimated coefficients for these variables (the level of each industry's output in the U.S., the relative inflation rate for each industry in Canada, non-oil GDP in Canada, the Canadian government expenditure, and the interest rate in Canada) in

[1] Because it takes time for related factors to show their effect on production plan.

[2] We did also estimate the equations in first difference form for the case that the reader is not convinced that the variables are cointegrated because, for many industries, the level of significance is outside the range of standard practice. However, the explanatory power of equations was very low and the variables were statistically insignificant in most cases. Thus, we decide not to report these results. This might be considered as a support for our conclusion that variables are cointegrated.

[3] In estimation of the models, we should note that:(a) All variables are seasonally adjusted and in real terms (except for interest rate). The U.S. and Canadian nominal variables have been converted to the real using implicit price indices in the U.S. and Canada respectively. (b) Although in finding the cointegration relationships we use equation 1.14 after including trend, for finding the long-run coefficients and residuals we use dynamic OLS (recommended by Stock and Watson (1993)) in which we also include the leads and lags of the first difference of the right hand side variables into the equation.

[4] See the sources of data in Appendix B.

long-run model are not inconsistent with the theoretical considerations.[1] Among them, the non-oil GDP in Canada, as a measure for changes in demand, is the most important variable which affects each industry's output with the elasticity of 2.33 in average. For 56 of the 80 industries, this variable is statistically significant.

The level of each industry's output in the U.S., as a proxy for the effects of unmeasured factors, is the next important variable which affects the dependent variable with the elasticity of 0.40 in average. For 38 of the 80 industries, this variable is statistically significant. The interest rate and government expenditures in Canada, which are the measures for fiscal and monetary policies, are much less important. The estimated coefficients of the interest rate are statistically significant for only 32 of the 80 industries and only for 19 of the 80 industries in the case of the government expenditures. The average of estimated coefficients for interest rate and government expenditures are -0.09 and 0.07 respectively.

The relative inflation rate for each industry in Canada is the least important variable. This variable is statistically significant for only eight of the 80 industries. The average of estimated coefficients for this variable is about 0.05.

The long-run estimations of the elasticity of output with respect to real exchange rate are presented in the sixth column of Table 1.3. Specifically, 53 of the 80 industries have positive estimates for this variable which indicate the existence of the Dutch Disease, but this coefficient is statistically significant for only 25 of those industries. Among the industries with positive coefficient for this variable, except for Leather Product [316], Computer and Peripheral Equipment [3341], Railroad Rolling Stock [3365], and Office Furniture [3372] which their coefficients are close to one, the estimates are less than one. The average of estimated elasticities for this group of industries (with positive effect) is about 0.34. Three industries show zero estimates for this variable: Veneer, Plywood and Engineered Wood Product Manufacturing [3212], Non-Metallic Mineral Product Manufacturing [327], and Ventilation, Heating, Air-Conditioning and Commercial Refrigeration Equipment Manufacturing [3334]. For other industries, 24 out of the 80 industries, the estimated coefficients are negative where only nine of them are statistically significant. The average of estimated elasticities among the industries with negative effect is about -0.38. The negative coefficients can be explained by this justification that these industries are not exposed to foreign competition and have enough ability to set their own prices. In fact, these industries cater for the home market as a result

[1] Except for the interest rate coefficient in Ship and Boat Building [3366] which is positive , and the relative inflation rate coefficient in Lime and Gypsum Product Manufacturing [3274] which is negative, other coefficients with unexpected sign are not statistically significant.

of trade protection or have monopolistic price-setting powers in their markets and, therefore, they may benefit from the rise in domestic demand as a result of the oil boom.

Table 1.3: Long-Run Effects of Output Determinants and Dutch Disease

Industry	US Out.	t	R. Inf.	t	Rexr	t	GDP	t	GEX	t	Int. Rate	t	R^2	DD	Simul.
311	0.51	1.35	0.02	0.22	0.14	2.18	0.39	0.88	0.46	3.2	0	-0.41	0.97	-0.08	0.39
3111	-0.46	-2.55	0.09	1.39	0.44	3.91	4.17	6.53	0.28	1.18	-0.05	-1.67	0.97	-0.24	1.23
3112	0.6	1.56	-0.03	-0.22	0.26	1.55	-2.55	-7.77	-0.49	-0.94	-0.1	-2.11	0.94	-0.14	0.73
3113	0.09	0.19	0.03	0.16	0.09	0.73	0.46	0.6	-0.27	-0.92	-0.06	-1.3	0.94	-0.05	0.25
3114	0.4	0.84	-0.02	-0.08	0.5	3.12	0.27	0.34	0.15	0.49	0.04	0.91	0.9	-0.27	1.40
3115	0.46	1.34	-0.39	-1.61	0.15	1.46	0.5	0.93	0.7	3.25	0	-0.28	0.6	-0.08	0.42
3118	0.45	1	-0.55	-0.89	0.34	3.03	-2.65	-3.59	-0.49	-1.27	0.1	0.31	0.81	-0.18	0.95
3121	0.81	2.04	-0.09	-0.49	0.1	1.02	2.44	2.98	0.37	1.98	-0.1	-3.82	0.89	-0.05	0.28
31211	0	-0.01	0.62	1.98	0.34	1.16	2.02	1.08	-1.26	-1.88	-0.14	-1.5	0.89	-0.18	0.95
313	0.67	1.63	-0.33	-0.36	0.62	2.48	3.39	2.39	1.19	1.34	-0.42	-5.8	0.96	-0.33	1.73
315	0.38	1.85	0.3	0.55	0.67	4.34	4.44	4.77	-0.55	-1.27	-0.15	-2.05	0.87	-0.36	1.87
316	0.33	0.73	-0.05	-0.09	0.98	2.97	4.5	4.51	-1.08	-1.52	-0.13	-1.05	0.95	-0.53	2.73
3169	0.29	3.73	0.38	2.22	0.45	3.09	3.7	7.9	-0.5	-1.86	-0.18	-5.62	0.98	-0.24	1.26
321	0.69	0.78	-0.04	-1.26	0.24	1.72	2.6	2.87	0.23	0.48	-0.17	-2.18	0.84	-0.13	0.67
3211	-1.31	-2.37	0	-0.12	-0.08	-0.45	2.75	5.42	0.88	1.82	-0.11	-1.63	0.89	0.04	-0.22
3212	-0.76	-2.23	0.02	0.95	0	-0.02	2.7	8.44	0.53	1.46	-0.15	-2.74	0.95	0.00	0.00
3219	0.29	2.05	0.14	0.81	0.24	2.86	2.83	5.68	-0.12	-0.67	-0.1	-3.66	0.76	-0.13	0.67
322	0.86	2.14	0.02	0.83	-0.14	-1.52	3.95	6.41	-0.14	-1.52	-0.1	-2.47	0.82	0.08	-0.39
32212	-0.06	-0.08	0.01	0.22	-0.22	-1.7	4.95	4.88	1.06	2.04	-0.1	-2.08	0.83	0.12	-0.61
3222	1.95	3.28	-0.03	-0.45	0.11	0.81	-0.83	-1.01	-0.24	-0.7	-0.22	-4.22	0.86	-0.06	0.31
32311	-0.76	-2.25	0.13	1.72	0.1	0.88	3.65	5.63	0.57	2.05	-0.13	-3	0.75	-0.05	0.28
32312	1.54	0.71	1.8	0.81	-0.79	-0.74	5.4	2.06	0.36	0.12	-0.97	-2.64	0.26	0.43	-2.20
324	0.34	0.53	-0.03	-1.4	0.42	3.52	1.19	1.68	0.25	0.89	-0.09	-2.57	0.86	-0.23	1.17
325	-0.99	-2.14	0.02	0.53	-0.21	-2.24	1.85	3.58	-0.16	-0.84	0	-0.02	0.97	0.11	-0.59
3251	-1.06	-2.37	0	-0.13	-0.45	-2.06	1.45	1.26	-0.47	-1.11	0.04	0.7	0.76	0.24	-1.26
3253	1.09	2.37	-0.09	-0.97	-1.25	-2.59	5.89	2.8	-1.77	-5.33	-0.06	-0.43	0.73	0.68	-3.49
3254	1.63	2.48	0.72	0.68	0.39	2.18	1.46	3.8	0.87	2.14	-0.21	-3.06	0.98	-0.21	1.09
3255	1.06	2.81	0.18	0.57	0.09	0.79	0.63	0.94	0.34	1	-0.07	-1.75	0.62	-0.05	0.25
326	0.78	2.8	-0.01	-0.18	0.03	0.37	1.82	3.28	-0.25	-0.94	-0.07	-2.3	0.98	-0.02	0.08
3261	0.65	1.97	0.09	0.95	0.08	0.73	3.15	4.79	-0.41	-1.36	-0.08	-2.09	0.98	-0.04	0.22

Table 1.3: Continued

Industry	US Out.	t	R. Inf.	t	Rexr	t	GDP	t	GEX	t	Int. Rate	t	R^2	DD	Simul.
3262	1.16	3.41	0.5	3.06	-0.18	-1.2	-0.6	-0.81	-0.21	-0.54	-0.06	-1.44	0.84	0.10	-0.50
327	-0.2	-0.33	-0.19	-1	0	-0.04	1.87	1.54	-0.74	-1.62	-0.05	-1.56	0.96	0.00	0.00
3272	-0.51	-0.27	-0.18	-0.36	0.26	0.55	-1.4	-0.51	-0.84	-0.66	-0.24	-1.63	0.76	-0.14	0.73
3273	-0.38	-0.48	-0.12	-0.44	-0.17	-0.77	2.56	1.64	-0.37	-0.64	-0.08	-1.76	0.96	0.09	-0.47
3274	1	2.17	-0.39	-1.73	0.01	0.06	-2.46	-2.55	-1.26	-1.39	-0.1	-1.15	0.73	-0.01	0.03
331	0.13	0.73	0.06	1.89	-0.13	-1.33	2.35	3.93	-0.25	-1.2	-0.06	-2.05	0.97	0.07	-0.36
3311	0.33	0.99	0.22	1.63	0.39	2.15	1.05	1.72	-0.61	-1.03	-0.07	-1.56	0.73	-0.21	1.09
3312	-1.06	-1.61	-0.2	-0.67	-0.53	-1.75	1.84	1.34	-1.15	-1.18	-0.01	-0.12	0.55	0.29	-1.48
3313	0.19	1.05	0.03	0.69	0.27	1.93	2.48	2.26	0.45	0.93	-0.02	-0.32	0.98	-0.15	0.75
3314	1.08	1.87	-0.06	-0.7	0.24	1.03	3.12	2.43	-1.2	-1.51	-0.18	-2.61	0.81	-0.13	0.67
3315	-0.1	-0.15	0.18	0.47	-0.69	-2.53	1.22	2.45	0.16	0.19	-0.1	-1.15	0.7	0.37	-1.93
332	0.75	4.67	0.03	0.43	0.29	4.14	2.5	11.11	-0.32	-1.7	-0.12	-4.08	0.98	-0.16	0.81
3321	-0.22	-0.36	-0.31	-0.94	-0.65	-2.01	2.8	6.5	1.01	1.43	-0.12	-1.11	0.68	0.35	-1.81
3322	-0.2	-0.3	1.09	1.06	-0.17	-4.09	4.41	7.34	-0.71	-0.71	-0.13	-1.1	0.91	0.09	-0.47
3323	0.64	2.94	0.17	0.9	0.14	1.76	5.61	10.78	0.1	0.37	-0.06	-1.37	0.97	-0.08	0.39
3324	-0.44	-0.71	0.18	0.24	-0.11	-0.43	1.88	1.7	0.97	1.04	-0.09	-0.79	0.72	0.06	-0.31
3325	0.58	1.7	-0.29	-0.33	0.41	2.99	3.8	3.52	0.53	1.15	0.01	0.24	0.83	-0.22	1.14
3326	0.78	1.16	-0.63	-0.59	0.68	3.02	2.05	5.7	0.84	2.34	-0.47	-6.36	0.94	-0.37	1.90
3327	0.06	0.1	-0.43	-0.69	0.11	0.39	3.7	5.16	-0.33	-0.39	0.05	0.53	0.9	-0.06	0.31
3328	0.36	1.39	0.1	0.7	0.22	1.55	3.04	4.31	-0.42	-1.1	-0.04	-0.95	0.89	-0.12	0.61
3329	0.34	0.46	-0.27	-0.56	0.67	3.09	2.72	1.91	1.83	2.44	-0.15	-1.41	0.79	-0.36	1.87
333	0.96	3.04	-0.24	-1.1	0.02	0.13	2.29	2.13	-0.06	-0.15	-0.16	-2.74	0.94	-0.01	0.06
33311	0.42	0.85	0.06	0.12	0.51	1.57	-1.83	-0.93	0.18	0.19	-0.16	-2.21	0.86	-0.28	1.42
33312	1.1	2.86	0.98	2.06	0.44	0.94	2.63	1.05	-0.62	-0.55	-0.28	-2.59	0.97	-0.24	1.23
3332	0.65	2.98	0.48	1.85	-0.18	-0.84	1.43	1.18	0.45	0.69	-0.19	-3.12	0.74	0.10	-0.50
3333	1.14	2.8	-0.12	-0.21	-0.1	-0.61	3.99	5.31	0.57	0.77	-0.11	-1.12	0.97	0.05	-0.28
3334	-1.12	-2.13	-0.06	-0.04	0	0.02	2.43	5.04	0.33	0.61	-0.1	-1.39	0.82	0.00	0.00
3335	0.75	1.01	-0.88	-1.06	-0.07	-0.19	1.75	0.88	-2.09	-1.69	-0.05	-0.39	0.51	0.04	-0.20
3336	1.18	1.74	0.62	1.62	0.29	0.94	1.55	2.23	-0.4	-0.42	-0.23	-1.65	0.73	-0.16	0.81
334	1.14	6.67	0.34	1.05	-0.35	-1.69	4.2	7.16	0.87	1.61	0.11	1.08	0.97	0.19	-0.98

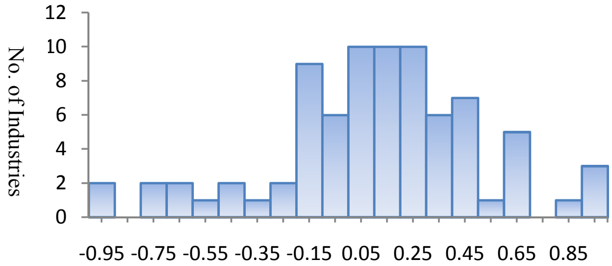
Table 1.3: Continued

Industry	**US Out.**	**t**	**R. Inf.**	**t**	**Rexr**	**t**	**GDP**	**t**	**GEX**	**t**	**Int. Rate**	**t**	R^2	**DD**	**Simul.**
3341	0.08	0.22	-0.14	-0.26	1.01	1.67	4.69	3.78	0.41	0.24	0	-0.03	0.96	-0.55	2.82
3342	0.92	1.3	0.84	1.24	-0.78	-1.1	5.38	1.11	0.28	0.16	0.32	1.11	0.94	0.42	-2.18
3344	1.12	1.25	0.57	0.92	-1.36	-1.58	10.68	1.19	-1.67	-0.94	-0.42	-2.62	0.92	0.73	-3.79
3345	-0.15	-0.24	-0.15	-0.3	0.18	1.21	1.73	1.86	-0.19	-0.39	0.04	0.62	0.91	-0.10	0.50
3346	-0.12	-1.78	0.44	0.22	-0.03	-0.05	5.82	1.95	1.17	0.78	-0.12	-0.73	0.5	0.02	-0.08
3351	-0.58	-1.92	0.15	0.2	0.35	2.89	2.21	2.84	-0.63	-1.5	-0.17	-3.24	0.76	-0.19	0.98
3352	0.01	0.03	-0.39	-0.86	0.67	3.69	-1.99	-1.87	-1.09	-2.6	-0.05	-0.96	0.86	-0.36	1.87
3353	1.02	2.32	0.08	0.55	0.11	0.51	5.32	5.48	-0.05	-0.12	-0.05	-0.77	0.9	-0.06	0.31
336	0.45	1.5	-0.11	-1.09	0.17	1.12	1.33	2.25	-0.49	-1.49	0.03	0.59	0.93	-0.09	0.47
3361	0.68	1.64	-0.05	-0.35	0.4	1.35	2.26	1.23	1.03	1.62	0.01	0.18	0.77	-0.22	1.12
3362	1.11	6.67	-0.15	-0.78	0.19	1.24	5.15	5.23	-1.65	-4.59	-0.03	-0.67	0.98	-0.10	0.53
3363	1.12	7.54	-0.13	-1.55	0.09	0.93	1.37	2.34	0	-0.02	-0.01	-0.56	0.97	-0.05	0.25
3364	-0.1	-1.11	0.04	0.52	-0.18	-1.17	2.73	4.77	-1.02	-2.89	0.05	1.09	0.96	0.10	-0.50
3365	1.7	3.52	-0.4	-1.03	1.11	2.85	1.15	0.39	0.36	0.4	-0.1	-0.51	0.93	-0.60	3.10
3366	0.06	0.11	0.36	1.26	-0.41	-1.4	0.44	0.21	2.44	3.94	0.21	2.18	0.67	0.22	-1.14
337	0.97	1.95	0.05	0.23	0.49	3.25	3.93	3.95	-0.89	-2.74	-0.07	-1.34	0.97	-0.26	1.37
3371	0.69	0.46	-0.24	-0.09	0.1	0.35	3.49	2.9	-0.75	-0.84	-0.18	-1.97	0.87	-0.05	0.28
3372	1.13	2.63	0.66	1.05	0.83	4.67	2.28	2.05	0.05	0.09	-0.06	-0.79	0.76	-0.45	2.32
3379	0.21	0.34	-0.19	-0.34	0.17	1.13	-1.4	-1.57	0.14	0.54	-0.01	-0.27	0.95	-0.09	0.47
339	0.81	1.13	-0.16	-1.01	0.24	1.6	1.08	1.27	-0.49	-1.49	-0.11	-2.25	0.97	-0.13	0.67

Notes: US Out. denotes the level of each industry's output in the U.S., R.Inf. shows the relative inflation rate for each industry in Canada, Rexr is the real exchange rate, GDP is the non-energy gross domestic product in Canada, GEX denotes the Canadian government expenditure, Int.Rate is interest rate in Canada, DD denotes the long-run Dutch Disease effect, t shows the t-statistics. Simul. is the result of a simulation that shows the average of percentage change in annual growth rate of each industry if energy price remained at its level in 1992.

The average of the long-run elasticity of output with respect to real exchange rate for the whole sample is 0.11. Figure 1.9 shows the variations of the long-run elasticity of output with respect to real exchange rate across industries.[1] As it can be observed, the estimates tend to be concentrated between -20 and 0.50 in a way that about 70 percent of industries are in this range.

Figure 1.9: Histogram for Long-Run Elasticity of Output with respect to Real Exchange Rate



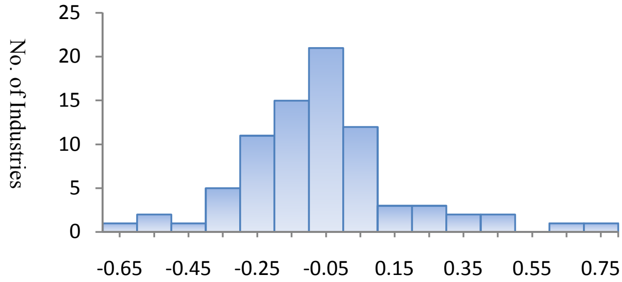
Corresponding to the long-run estimations of the elasticity of output with respect to real exchange rate, we have calculated the long run Dutch Disease effect in each industry (the effect of one percent change in energy prices on the output of each industry) using the long run elasticity of real exchange rate with respect to energy prices obtained from the long run real exchange rate equation (-0.54).[2] Therefore, the pattern of Dutch Disease effect across industries is similar to the one obtained for the long-run elasticity of output with respect to real exchange rate. As the related column of Table 1.3 (DD) indicates, 53 of the 80 industries experience decrease in their output as a result of increase in energy prices with the elasticity of -0.18 in average (after control for all major determinants including the role of energy as an input). This reaction is zero for three industries and is positive for 24 industries with the elasticity of 0.21 in average.

The average of the long-run Dutch Disease elasticity for the whole sample is -0.06. Figure 1.10 shows the variations of the long-run Dutch Disease effect across industries. As it can be observed, this elasticity tends to be concentrated between -0.30 and 0.10 in a way that about 75 percent of industries are in this range.

[1]The horizontal axis shows the range of the estimated coefficients for the real exchange rate and the vertical axis shows the number of industries.

[2]Dutch Disease effect is, in fact, equal to the long-run elasticity of output with respect to real exchange rate times -0.54. However, note that this Dutch Disease effect is for the time period after 2003q3. For the time period 1992q1-2003q3, Dutch Disease effect is equal to the long-run elasticity of output with respect to real exchange rate times -0.15. In fact, Dutch Disease effect for 1992q1-2002q3 is equal to 28 percent of the values reported in the Table 1.3.

Figure 1.10: Histogram for Long-Run Dutch Disease Effect



To provide a clean answer to the question of this paper that whether Canada has caught Dutch Disease as a result of the oil boom during 1992-2007, we do a counterfactual simulation based on the weighted average of long-run Dutch Disease elasticity for each industry during this time period.[1] This counterfactual simulation estimates the average of percentage change in annual growth rate of each industry by assuming that the real energy price and therefore the share of energy's trade balance in total commodities' trade balance remained at their levels in 1992 (see the results in last column of Table 1.3). During 1992-2007 the annual increase in the real energy price adjusted by the share of energy's trade balance has been 11 percent on average. Thus, the simulation results are equal to the weighted average of long run Dutch Disease elasticities multiplied by -11.[2]

Based on the provided results, among the industries that suffer from Dutch Disease (53 industries), each industry could experience more annual output growth by 0.93 percent on average if energy price remained at its level in 1992. However, this change would substantially vary across industries. On the other hand, among the industries that benefit from the oil boom (24 industries), each industry would experience less annual output growth by 1.07 percent on average if energy price remained unchanged. Based on the results for whole sample, each industry could experience more annual output growth by 0.30 percent on average, although it varies substantially across industries. Considering that the average of annual industrial production growth has been 2.8 percent for 1992-2007, the simulation results imply that the annual output growth of each industry has decreased by about 11 percent on average as a result of the oil boom during this time period.

[1] Considering that the long-run elasticity of real exchange rate with respect to the energy prices is different for the time periods before and after 2003q4, for this simulation we need to calculate the weighted average of long-run Dutch Disease elasticity for each industry. This elasticity is equal to the long-run elasticity of output with respect to real exchange rate for each industry multiplied by the weighted average of long-run elasticity of real exchange rate with respect to the energy prices ($-0.253 = -0.15 * \frac{47}{64} + -0.54 * \frac{17}{64}$).

[2] The simulation results are, in fact, equal to the the long-run elasticity of output with respect to real exchange rate for each industry (reported in the sixth column of Table 1.3) multiplied by $2.79 = -0.253 * -11$.

The contemporaneous and short-run effects (after two quarters)[1] of output determinants are reported in Table 1.4. As it was expected, the contemporaneous and short run effects of most output determinants are lower than the long run effects. Based on the provided results, the average of contemporaneous effects for level of each industry's output in the U.S. is 0.15 (versus 0.40 in the long run), for non-oil GDP in Canada is 1.5 (versus 2.33 in the long run), for the Canadian government expenditure is zero (versus 0.07 in the long run), and for the interest rate in Canada is -0.05 (versus -0.09 in the long run).

The contemporaneous estimations of the elasticity of output with respect to real exchange rate are presented in the sixth column of Table 1.4. 59 of the 80 industries have positive estimates for this variable which indicate the occurrence of the Dutch Disease even in the same period, but this coefficient is statistically significant for only 17 of those industries. For the industries with positive coefficients, the estimated elasticities are less than one with the average of 0.25 and it increases to 0.30 in the short-run. Two industries show zero estimates for this variable: Veneer, Plywood and Engineered Wood Product Manufacturing [3212], and Paint, Coating and Adhesive Manufacturing [3255]. For other industries, 19 out of the 80 industries, the estimated coefficients are negative where only two of them are statistically significant. For the industries with negative coefficients, the estimated elasticities are less than one with the average of -0.22 and it decreases to -0.33 in the short-run.

[1] The AIC has been considered as the measure for choosing the number of the dependent variable lags. Based on this measure, the maximum number of lags is two quarters. The short-run effects are calculated based on this formula: Contemporaneous effect/(1-(Coefficient of lag1+Coefficient of lag2)).

Table 1.4: Short-Run Effects of Output Determinants and Dutch Disease

Ind.	**US Out.**	**t**	**R.Inf.**	**t**	**Rexr**	**t**	**GDP**	**t**	**GEX**	**t**	**Int.Rate**	**t**	**Dev.**	**t**	**Lag1**	**t**	**Lag2**	**t**	R^2	**C.DD**	**S.DD**
311	0.01	0.07	-0.01	-0.24	0.13	2.38	0.78	2.08	-0.01	-0.65	0.01	1.2	0.2	1.63					0.15	-0.01	-0.04
3111	-0.34	-1.52	0.09	1.92	0.28	1.74	2.76	2.54	-0.03	-0.58	0	0.19	0.55	2.67					0.28	-0.03	-0.08
3112	0.66	1.57	-0.02	-0.81	-0.01	-0.07	-1.94	-1.45	0.02	0.45	-0.01	-0.22	0.19	0.76					0.11	0.00	0.00
3113	-0.38	-0.71	-0.14	-1.65	-0.2	-0.99	0.05	0.04	-0.03	-0.44	0.05	0.96	0.65	4.02					0.22	0.02	0.06
3114	-0.1	-0.2	0.01	0.07	0.49	2.63	0.2	0.16	0	-0.11	0.05	1.06	0.36	2.94					0.15	-0.05	-0.15
3115	0.18	0.7	-0.14	-1.02	0.03	0.36	0.7	1.03	-0.01	-0.47	0.01	0.56	0.3	1.81					0.15	0.00	-0.01
3118	0.37	0.85	-0.32	-1	0.48	2.86	0.35	0.29	-0.06	-0.93	0.02	0.48	0.5	2.55					0.2	-0.05	-0.14
3121	0.14	0.32	-0.09	-0.72	0.19	1.25	0.91	1.01	-0.03	-0.77	-0.05	-1.51	0.49	2.25					0.03	-0.02	-0.06
31211	0	0	0.21	0.81	-0.27	-0.92	0.68	0.39	-0.07	-0.76	-0.12	-1.72	0.38	2.53	0.41	2.48			0.13	0.03	0.14
313	0.19	0.41	0.09	0.18	0.37	1.18	0.22	0.1	-0.03	-0.31	-0.09	-1.23	0.4	1.63	0.47	2.13			0.21	-0.04	-0.21
315	0.17	0.57	-0.1	-0.3	0.17	0.75	3.72	3.09	-0.1	-1.25	-0.03	-0.64	0.17	1.02					0.12	-0.02	-0.05
316	0.05	0.09	-0.03	-0.09	0.29	0.65	2.83	1.99	0.08	0.59	-0.15	-1.47	0.25	1.38					0.06	-0.03	-0.09
3169	0.01	0.1	0.15	1.44	0.06	0.46	1.83	2.08	0	-0.1	-0.1	-3.41	0.29	1.59					0.26	-0.01	-0.02
321	0.05	0.14	-0.03	-2.04	0.45	2.47	1.66	2.76	-0.07	-1.23	-0.14	-3.09	0.39	1.65					0.39	-0.05	-0.14
3211	-0.02	-0.03	0	-0.03	0.39	1.56	0.56	0.32	0.09	1.21	-0.14	-2.2	0.39	1.16					0.19	-0.04	-0.12
3212	-0.51	-1.23	0.02	1.66	0	-0.05	1.5	1.06	0.15	2.26	-0.07	-1.39	0.93	3.37	0.26	1.64			0.37	0.00	0.00
3219	0.2	0.82	0.09	1.06	0.15	1.4	1.31	1.78	0	-0.06	-0.05	-1.82	0.08	0.46					0.15	-0.02	-0.05
322	-0.3	-0.88	0.01	0.99	0.06	0.52	0.5	0.48	-0.02	-0.51	-0.01	-0.48	0.5	2.54					0.2	-0.01	-0.02
32212	-0.33	-0.88	0	-0.27	0.07	0.5	1.72	1.4	-0.01	-0.27	-0.05	-1.22	0.32	1.21	0.66	3.41	-0.25	-1.6	0.34	-0.01	-0.04
3222	0.24	0.7	-0.01	-0.56	0.31	2.34	-0.34	-0.38	0.06	1.27	-0.03	-0.99	0.53	3.44	0.47	3.16			0.3	-0.03	-0.18
32311	0.34	1.01	0	-0.1	-0.1	-0.83	0.5	0.57	0.04	0.88	-0.01	-0.46	0.49	3.83	0.38	2.78	0.39	2.51	0.39	0.01	0.13
32312	0.24	0.26	0.45	0.72	0.06	0.15	2	0.65	-0.08	-0.48	-0.08	-0.64	0.58	4.63	0.54	4.1			0.42	-0.01	-0.04
324	0.61	1.46	-0.01	-0.75	0.25	1.89	1.19	1.31	0.04	0.87	-0.04	-1.29	0.63	3.45	0.19	1.28	0.37	2.51	0.22	-0.03	-0.17
325	-0.14	-0.49	-0.02	-0.96	0.04	0.43	2.84	4.17	-0.06	-2.01	-0.03	-1.35	0.3	2.02					0.32	0.00	-0.01
3251	-0.48	-1.36	-0.03	-1.26	-0.05	-0.27	0.84	3.06	-0.11	-1.79	0	0.12	0.38	2.71					0.23	0.01	0.02
3253	0.11	0.15	-0.03	-1.14	-0.76	-1.93	4.11	1.76	0.05	0.43	0.07	0.8	0.17	3.61					0.28	0.08	0.23
3254	-0.31	-0.45	-0.5	-0.76	-0.09	-0.38	0.23	0.15	0	-0.05	-0.05	-0.98	0.59	3.57					0.28	0.01	0.03
3255	0.49	0.96	-0.19	-0.92	0	-0.03	1.32	0.99	-0.02	-0.27	-0.12	-2.19	0.62	2.37					0.16	0.00	0.00
326	0.42	1.33	-0.03	-0.67	0.13	1.17	1.53	1.87	-0.02	-0.71	-0.09	-3.14	0.52	3.02					0.34	-0.01	-0.04
3261	0.39	1.08	0.01	0.18	0.18	1.43	2.25	2.41	-0.03	-0.73	-0.1	-3.04	0.6	3.6					0.38	-0.02	-0.05

Table 1.4: Continued

Ind.	**US Out.**	**t**	**R. Inf.**	**t**	**Rexr**	**t**	**GDP**	**t**	**GEX**	**t**	**Int. Rate**	**t**	**Dev.**	**t**	**Lag1**	**t**	**Lag2**	**t**	R^2	**C.DD**	**S.DD**
3262	0.24	0.68	0.17	1.78	-0.02	-0.14	-0.83	-0.74	0	-0.13	-0.04	-1.19	0.59	3.54	0.32	2.29			0.21	0.00	0.01
327	-0.07	-0.17	-0.14	-1.6	0.08	0.59	-0.66	-0.62	-0.03	-0.6	0	-0.13	0.68	4.32	0.55	3.25			0.27	-0.01	-0.05
3272	0.6	0.82	-0.28	-1.54	-0.18	-0.64	-0.97	-1.55	0.12	1.23	-0.12	-1.56	0.25	1.54	0.32	1.66			0.21	0.02	0.08
3273	-0.33	-0.54	-0.2	-1.47	0.17	0.66	0.16	0.1	-0.08	-1.07	-0.01	-0.29	0.61	3.97	0.4	2.5			0.2	-0.02	-0.09
3274	0.36	0.83	-0.23	-2.56	-0.1	-0.36	-1.07	-1.64	0.03	0.35	0.04	0.54	0.65	2.94					0.23	0.01	0.03
331	-0.16	-0.8	0.01	0.86	0.03	0.34	2.47	3.34	0	-0.16	-0.06	-2.2	0.5	2.99					0.26	0.00	-0.01
3311	-0.31	-0.59	0.17	2.01	0.23	0.65	1.69	1.57	-0.04	-0.38	-0.18	-1.93	0.54	1.24					0.11	-0.03	-0.07
3312	-1.25	-2.68	0.09	0.65	-0.38	-1.38	1.96	2.08	-0.2	-1.91	-0.06	-0.79	0.73	3.12					0.31	0.04	0.11
3313	0.07	0.29	-0.03	-0.96	-0.08	-0.36	-0.86	-0.47	0.03	0.57	0.06	1.41	0.45	1.92	1.12	5.6	-0.49	-1.92	0.58	0.01	0.06
3314	-0.21	-0.41	-0.03	-1.13	0.21	0.64	2.75	1.44	-0.11	-1.05	-0.11	-1.32	0.86	3.04					0.19	-0.02	-0.06
3315	-0.54	-1.36	-0.06	-0.66	-0.6	-3.04	0.58	0.41	0.04	0.53	-0.02	-0.42	0.23	1.09					0.1	0.07	0.18
332	0.24	0.92	0.03	0.84	0.2	1.78	1.89	5.23	0	-0.24	-0.05	-2	0.45	3.21					0.45	-0.02	-0.06
3321	0.33	0.41	0	0	-0.07	-0.17	1.46	0.82	-0.1	-0.68	-0.13	-1.22	0.93	4.22	0.31	1.87			0.34	0.01	0.03
3322	0.95	0.93	0.02	0.04	0.03	0.08	2.71	1.59	0.02	0.16	-0.19	-1.45	0.72	2.28					0.15	0.00	-0.01
3323	0.19	0.49	0.23	1.73	0.26	1.41	4.83	3.86	-0.03	-0.44	-0.01	-0.28	0.82	3.57					0.43	-0.03	-0.08
3324	-0.4	-0.64	0.07	0.32	-0.28	-0.99	0.03	0.01	-0.12	-1.44	-0.11	-1.53	0.5	2.76					0.19	0.03	0.08
3325	0.19	0.32	-0.67	-1.17	0.47	1.75	0.01	0	0	0.06	0.04	0.51	0.58	1.65					0.2	-0.05	-0.14
3326	-0.27	-0.49	-1.55	-2.8	0.35	1.39	1.4	0.69	0.09	0.94	-0.07	-0.82	0.44	1.56	0.79	3.82			0.45	-0.04	-0.50
3327	-0.02	-0.05	-0.2	-0.72	0.09	0.46	2.45	2.83	0.05	0.6	-0.01	-0.16	0.53	2.36					0.21	-0.01	-0.03
3328	0	0	-0.03	-0.29	0.34	1.11	2.83	2.37	-0.11	-1.18	-0.14	-1.9	0.72	2.77					0.25	-0.04	-0.10
3329	0.19	0.38	-0.32	-1.52	0.36	1.6	2.68	3.74	0.05	0.67	-0.24	-3.61	0.77	3.16					0.48	-0.04	-0.11
333	0.54	1.99	0.02	0.25	0.31	2.25	1.95	2.01	0.02	0.49	-0.04	-1.12	0.49	3.9					0.33	-0.03	-0.09
33311	0.35	0.86	0.25	1.95	0.4	1.09	0.44	1.03	-0.01	-0.13	-0.16	-1.73	0.22	0.96					0.12	-0.04	-0.12
33312	0.68	1.34	0.07	0.48	0.24	0.48	-0.63	-0.19	0.06	0.5	-0.11	-1.12	0.82	2.69	0.2	0.91			0.16	-0.03	-0.09
3332	0.44	1.51	0.37	2.01	0.13	0.43	-1.61	-0.55	0.02	0.25	-0.03	-0.48	0.61	2.04					0.27	-0.01	-0.04
3333	0.34	0.7	-0.28	-1.21	0.22	0.74	2.79	2.95	0.09	0.83	-0.13	-1.47	0.71	2.08					0.29	-0.02	-0.07
3334	0.28	0.43	0.08	0.09	0.25	0.96	2.75	3.32	-0.07	-0.8	-0.05	-0.77	0.69	4.03					0.39	-0.03	-0.08
3335	0.76	0.98	-0.38	-0.59	0.11	0.26	-0.86	-0.27	-0.02	-0.14	-0.13	-0.99	0.64	2.07					0.18	-0.01	-0.03
3336	0.75	0.98	0.67	3.25	0.95	2.3	1.99	3.17	-0.04	-0.26	-0.34	-2.73	0.27	1.21					0.31	-0.10	-0.29
334	1.04	1.92	0.1	0.86	0.18	0.45	2.91	2.26	0.06	0.47	-0.01	-0.19	0.46	1.39					0.26	-0.02	-0.05

Table 1.4: Continued

Ind.	US Out.	t	R. Inf.	t	Rexr	t	GDP	t	GEX	t	Int. Rate	t	Dev.	t	Lag1	t	Lag2	t	R^2	C.DD	S.DD
3341	0.24	0.62	-0.1	-1.2	0.2	0.49	4.55	1.56	0.05	0.34	-0.1	-0.98	0.48	4.3	0.47	3.3			0.42	-0.02	-0.11
3342	-0.01	-0.01	0.1	0.5	-0.19	-0.25	2.63	1.91	-0.08	-0.32	0.01	0.06	0.26	0.86					0.06	0.02	0.06
3344	1.46	1.37	0.02	0.19	-0.23	-0.32	11.2	4 1.50	0.4	1.42	-0.3	-1.33	1.02	3.71	0.81	3.71			0.53	0.03	0.36
3345	-0.19	-0.22	-0.29	-0.7	0.29	1.01	1.17	0.58	0.16	1.42	0.01	0.2	0.61	2.68					0.09	-0.03	-0.09
3346	-0.54	-0.63	-0.54	-0.44	0.13	0.22	2.76	0.71	0.1	0.45	0.13	0.79	0.37	1.33	0.52	2.78			0.08	-0.01	-0.08
3351	-0.95	-1.83	-0.14	-0.29	0.38	1.69	3.92	2.29	0.01	0.13	0	-0.01	0.97	3.94					0.35	-0.04	-0.11
3352	0.18	0.3	-0.33	-1.08	0.55	2.22	0.27	0.15	-0.13	-1.49	-0.15	-2.12	0.85	4.16					0.39	-0.06	-0.17
3353	1.25	3.21	0.06	1.08	0.51	2.89	2.69	2.11	0.03	0.58	-0.03	-0.89	0.49	3.71					0.45	-0.06	-0.15
336	0.26	1.02	-0.06	-1.08	0.12	0.82	1.2	1.27	-0.04	-0.9	-0.08	-2.31	0.32	2.36					0.27	-0.01	-0.04
3361	0.51	1.23	-0.07	-1.34	0.7	2.33	2.09	0.95	-0.04	-0.51	-0.19	-2.66	0.48	2.34	0.02	0.16	-0.03	-0.2	0.34	-0.08	-0.21
3362	0.8	2.39	-0.11	-0.79	0.23	0.85	2.43	1.28	0	0.09	-0.04	-0.75	0.59	2.77					0.33	-0.03	-0.07
3363	0.5	1.67	-0.07	-1.46	0.08	0.51	0.84	0.68	-0.06	-1.37	-0.09	-2.27	0.49	2.06	-0.29	-1.76	-0.34	-2.28	0.4	-0.01	-0.01
3364	-0.21	-1.95	0	-0.1	-0.19	-1.6	1.06	1.42	0	0.05	0	0.25	0.3	2.91	0.36	2.47	0.17	1.71	0.51	0.02	0.12
3365	0.81	2.75	-0.06	-1.27	0.12	0.66	1.04	2.09	0	0.04	-0.16	-2.87	0.25	3.26	0.41	3.42	0.2	1.72	0.67	-0.01	-0.09
3366	0.18	0.2	0.37	2.75	-0.4	-1.06	0.47	0.93	0.07	0.6	0.18	1.94	0.52	2.74	0.33	2.25			0.25	0.04	0.18
337	0.01	0.02	0.09	0.75	0.39	2.32	3.66	3.03	-0.05	-0.98	-0.02	-0.68	0.32	1.95					0.21	-0.04	-0.12
3371	-0.74	-1.33	-0.08	-0.1	0.19	0.86	3.64	2.7	-0.04	-0.47	-0.06	-0.93	0.23	1.19					0.09	-0.02	-0.06
3372	0.91	2.54	0.12	0.52	0.68	3.37	4.21	2.72	-0.02	-0.34	0.03	0.63	1.04	5.26					0.61	-0.07	-0.20
3379	0.07	0.18	-0.6	-1.07	0.05	0.28	0.08	0.06	0.14	1.79	0	-0.14	0.75	3.1					0.18	-0.01	-0.02
339	0.46	0.84	-0.08	-1.03	0.23	1.31	-0.54	-0.45	0.04	0.76	-0.02	-0.55	0.47	2.83					0.11	-0.03	-0.07

Notes: US Out. denotes the level of each industry's output in the U.S., R.Inf. shows the relative inflation rate for each industry in Canada, Rexr is the real exchange rate, GDP is the non-energy gross domestic product in Canada, GEX denotes the Canadian government expenditure, Int.Rate is interest rate in Canada, Dev. shows the speed of adjustment back to long-run equilibrium. Lag1 and 2 denote the first and second lags of dependent variable, respectively. C.DD and S.DD denote the contemporaneous and short-run Dutch Disease effects, respectively. t shows the t-statistics.

The average of the contemporaneous and the short-run elasticities of output with respect to real exchange rate for the whole sample are 0.14 and 0.15 respectively. Figures 1.11 and 1.12 respectively show the variations of the contemporaneous and the short-run elasticities of output with respect to real exchange rate across industries. As it can be observed, the contemporaneous elasticities tend to be concentrated between -0.10 and 0.40 in a way that about 75 percent of industries are in this range. The same pattern is observed for the short run elasticities.

Figure 1.11: Histogram for Contemporaneous Elasticity of Output with respect to Real Exchange Rate

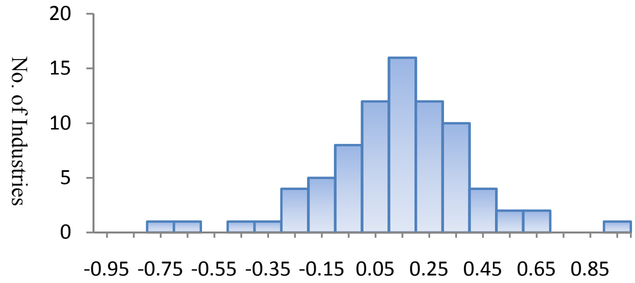
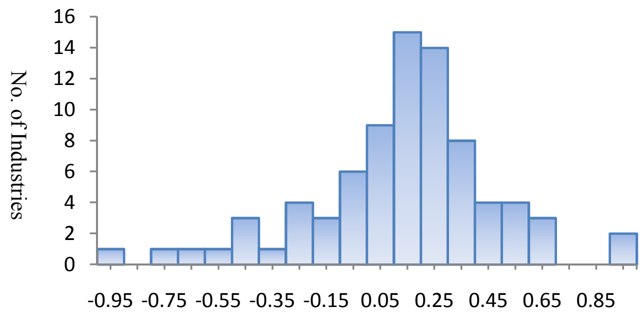


Figure 1.12: Histogram for Short-Run Elasticity of Output with respect to Real Exchange Rate



Corresponding to the contemporaneous and short-run estimates for the elasticities of output with respect to real exchange rate, we have calculated the contemporaneous and the short-run Dutch Disease effects in each industry using the contemporaneous and the short-run elasticities of the real exchange rate with respect to energy prices obtained from the related real exchange rate equation (-0.11 and -0.30 respectively). As the two last columns of Table 1.4 indicate, 59 of the 80 industries experience decrease in their output as a result of increase in energy prices (after control for all major determinants including the role of energy as an input). This reaction is zero for two industries and is positive for 19 industries. The average of the contemporaneous and the short-run Dutch Disease elasticities for the whole sample are -0.015 and -0.045 respectively.[1] Figures 1.13 and 1.14 show the variations of the contemporaneous and short-run Dutch Disease effects across industries respectively. As it can be observed, the contemporaneous Dutch Disease elasticity is between 0 and -0.10 for 63 industries and is between 0 and 0.10 for other industries. On the other hand, the short run Dutch Disease elasticity tends to be concentrated between -0.20 and 0.10 in a way that about 80 percent of industries are in this range.

Figure 1.13: Histogram for Contemporaneous Dutch Disease Effect

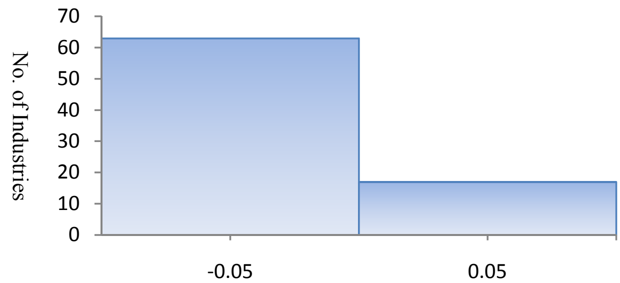


Figure 1.14: Histogram for Short-Run Dutch Disease Effect

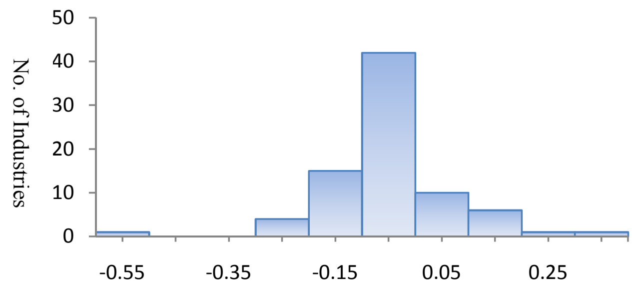


Table 1.5 provides the average of the contemporaneous and long-run Dutch Disease elasticities as well as the counterfactual simulation results (indicating the average of percentage change in annual growth rate of each industry if energy price remained at its level in 1992) across major manufacturing industries (3-digit NAICS).

[1]Among the industries that suffer from Dutch Disease (59 industries), the average of the contemporaneous and short-run Dutch Disease elasticities are -0.03 and -0.09 respectively, while they are 0.03 and 0.11 for the industries that benefit from Dutch Disease (19 industries).

Table 1.5: Cross-Industry Variation in Dutch Disease Effect

NAICS	N	C-Dutch Disease	LR-Dutch Disease	Simul.
Food	6	-0.02	-0.16	0.84
Beverage	2	0.00	-0.12	0.60
Textile mills	1	-0.04	-0.33	1.71
Clothing	1	-0.02	-0.36	1.87
Leather	2	-0.02	-0.39	1.99
Wood	3	-0.02	-0.03	0.16
Paper	2	-0.02	0.03	-0.16
Printing	2	0.00	0.19	-0.96
Petroleum	1	-0.03	-0.22	1.16
Chemical	4	0.02	0.16	-0.84
Plastic	2	-0.01	0.03	-0.16
Non-metallic mineral	3	0.00	-0.02	0.08
Primary metal	4	0.01	0.03	-0.16
Fabricated metal	9	-0.02	-0.08	0.40
Machinery	7	-0.04	-0.07	0.36
Computer	5	0.00	0.11	-0.56
Electrical equipment	3	-0.05	-0.20	1.04
Transportation equipment	6	-0.01	-0.11	0.56
Furniture	3	-0.03	-0.20	1.04
Miscellaneous	1	-0.02	-0.13	0.68

Notes: C-Dutch Disease denotes the average of estimates of the contemporaneous Dutch Disease elasticities. LR-Dutch Disease shows the average of estimates of the long-run Dutch Disease elasticities. N is the number of 4 and 5 digit NAICS industries included in the study. Simul. shows the counterfactual simulation results.

While the contemporaneous effect is not considerable for most of the industries, the long-run results indicate a type of dichotomy such that some industries suffer from the Dutch Disease and some industries benefit from this phenomenon. As it can be observed, Leather [316], Clothing [315], and Textile mills [313] industries suffer severely from Dutch Disease (their long run elasticities are around -0.35) and to a lesser extent, this negative effect is observed in Petroleum [324], Electrical equipment [335] and Furniture industries [337] (their long run elasticities are around -0.20). Food [311], Beverage [312], Transportation equipment [336] and Miscellaneous [339] industries are also significantly suffering from the Dutch Disease. On the other hand, it seems that industries like Printing [323] and Chemical [327] may benefit from Dutch Disease phenomenon (their long run elasticities are around 0.20).

The beneficiary effect of Dutch Disease can be explained by this justification that these industries are not probably exposed to foreign competition and have enough ability to set their own prices. In fact, these industries may cater for the home market as a result of trade protection or have monopolistic price-setting powers in their markets and, therefore, they may benefit from the rise in domestic demand as a result of the oil boom. This interpretation is supported by looking at two measures for market power: the degree of product differentiation and the share of imports from U.S. in the domestic supply for each industry.[1] For example, the

[1] Intra-industry trade is used as a measure for the degree of product differentiation (with positive relationship). High (low) values for this measure and low (high) values for share of imports indicate high (low) degree of market power for domestic producers. See the definitions and sources of data in Appendix E.

degree of product differentiation and the share of imports for Electrical equipment industry, as the one suffers from the Dutch Disease, are respectively 0.12 and 0.60 implying low degree of market power compared to 0.29 and 0.38 as the average values of the sample. On the other hand, for Printing industry, as the one benefits from the Dutch Disease, these measures are respectively 0.50 and 0.07 implying high degree of market power compared to the average values of the sample. Therefore, as discussed in theoretical section, market structure in terms of the market power might be one of the factors determining the effect of resource boom on different industries.

The provided results in Table 1.5 are also informative about the extent of the potential harmful effects that Dutch Disease might have on the Canadian economy in terms of lower technological spillovers and innovation and therefore, permanently lower rates of growth in the economy. In this regard, it seems the government should not be worry too much because as discussed, the Dutch Disease effect is beneficial for some industries like Chemical and Printing and is insignificant for some other industries. More importantly, although some industries like Leather, Clothing, and Textile industries suffer severely from Dutch Disease, the general perception is that these ones should not be the significant sources of innovation. The only concern is about the Electrical equipment and Transportation equipment industries that suffer significantly from Dutch Disease and are expected to be the potential sources of innovation.

After finding some evidence of Dutch Disease in Canadian economy (at least in some industries), it may be reasonable to ask that what Canada can do to immunize its economy against this disease. Although the focus of this study is to examine whether Canadian industries have experienced the Dutch Disease, we briefly explain some policies may lead to success in avoiding the Dutch Disease based on the experience of the other countries like Norway.[1] Before looking at these policies, it is important to note that the structure of the Canadian government would make replicating these policies relatively difficult. Since royalties on resource revenues are within provincial jurisdiction, it might not be feasible to obtain a coordinated response from all levels of government.

Limit Wage Increases: As it was explained in the Dutch Disease theory, rising labour costs exacerbate the loss of competitiveness of the industries in tradable sector. In Norway, salary increases were limited to the rate of growth in productivity of the manufacturing sector, partly because of the Norway's highly centralized wage negotiation system. Thus, Norway was

[1]For more details, see Bergevin (2006), Usui (1997) and Bjϕrnland (1998).

able to avoid a situation where significant wage increases in the growing resource sector led to upward pressure on wages in the rest of the economy. Although centralized wage negotiation system would not be feasible in Canada, governments within their sphere of influence can try to link salaries to growth in productivity in order to limit upward pressure on wages and prices.

Avoid Excessive Government Spending by Saving the Resource Revenues in a Fund : In order to reduce the pressure on the domestic economy and the domestic currency, the Norwegian government adopted fiscal policies that involved fiscal discipline, debt reduction and the establishment of a petroleum fund. Within Canada, the Alberta government can show similar discipline, eliminate its net debt; and deposit a significant share of resource royalties to a fund. This saving can be invested by government in the international financial markets. Because of the volatile nature of resource revenues, the savings available in the fund can be used to "even out" government revenues between good and bad times. Moreover, using tax policies, government can encourage the oil companies to reinvest the energy revenues in international financial markets or reinvest in oil sector by importing capital intensive technologies. This policy may reduce aggregate demand and the inflationary pressures associated with oil revenues.

Investment Use of the Resource Royalties to Facilitate the growth of the Tradable Sector: Government can spend oil royalties to strengthen the tradable sector. In the theoretical context, the first best method would be to subsidize the tradable sector directly with funds from the oil revenues. That is, the government policy as to how to spend the oil revenues is very importance in assessing the effects of Dutch Disease. Direct subsidies for some inputs like energy, investment in infrastructures, research and innovation as well as new technologies can improve the competitiveness of the tradable sector and thus mitigate the effects of the Dutch Disease.

1.5 Summary and Conclusions

The experience of the resource-rich countries suggests that natural resource wealth can be a double edge sword. On one side, it can help to economic development and higher standard of living through raising national income. However, on the other side, it may lead to lower and imbalanced growth across the other sectors of the economy. In the economic literature, this phenomenon is called Dutch Disease which originally refers to the adverse effects of the natural gas discoveries of the 1960s on Dutch manufacturing, mainly through the subsequent appreciation of the Dutch real exchange rate. The mechanism of the Dutch Disease is clear. Part of the boom revenues is spent on the non-tradable goods which leads to an appreciation of the real exchange rate, which in turn draws resources out of the tradable sector (manufacturing), to the extent that this sector is exposed to international competition, into the non-tradable sector (services). Moreover, the increased profitability of a booming sector bids up the prices of factors of production, which results in a contraction of tradable sectors due to the reduction in production factors. Considering that the manufacturing sector tends to be more innovative than other sectors and is a source of technological spillovers, Dutch Disease may lead to permanently lower rates of growth in the economy.

Since the early 1990s, the Canadian energy sector has experienced solid growth. Supported by investment, which has nearly doubled over this period, energy production has significantly increased. Total oil production has increased by nearly 67 per cent from 89 million cubic meters in 1991 to around 150 million cubic meters in 2007, while natural gas production has increased by over 84 per cent from 113,490 million cubic meters in 1991 to around 209,362 million cubic meters in 2007. As a result, Canada has become an important player in world energy markets and is currently the seventh and third largest producer of oil and natural gas, respectively. Canada's position of a net exporter of energy is expected to remain firm given plans to continue developing the vast oil sand deposits. The inclusion of these deposits would give Canada the world's second largest proven reserves.

Considering the adverse effects of the Dutch Disease, appearing in the form of imbalanced growth across the various sectors of the economy, the main purpose of this study is to examine whether Canadian manufacturing industries have experienced the Dutch Disease over the period 1992-2007 as a result of the oil boom. The results of this research are very important for policy makers. If the Dutch Disease hypothesis is confirmed and policy makers recognize that this disease is costly for the economy, they can protect the economy from it by implementing the appropriate policies which have been successfully used in other countries like Norway. These policies may include the investment use of the resource royalties to facilitate the growth of the tradable sector (investment in research and innovation), subsidies to maintain manufacturing output, saving the resource royalties in a Fund and use this saving to invest in the international capital markets, and limiting wage increases to the rate of growth in productivity of the manufacturing sector. To reach the goal, at first, a review of theoretical and empirical studies related to the Dutch Disease was provided. In addition to providing a reference to compare our findings, this review helps us in considering the related variables and choosing the appropriate measure for them. Then, in the next section, the static and dynamic aspects of the Dutch Disease theory were discussed in detail. In our empirical work, at first, we estimated the relationship between real exchange rate and energy prices using an error correction model. Then, we examined the effect of real exchange rate on output of the manufacturing industries. Based on these two estimations, we calculated the Dutch Disease effect (the effect of energy prices on output of the manufacturing industries).

The long run estimation results for real exchange rate equation suggest that energy and other commodities both play an important role in explaining real exchange rate trends. The results also show that the relationship between energy and other commodity prices and the Canadian real exchange rate has changed after the fourth quarter of 2003. In the time period between 1992 and the third quarter of 2003, one percent increase in energy prices led to appreciation of the Canadian real exchange rate by 0.15 percent, keeping other things constant. However, after the third quarter of 2003, this effect increased to 0.54 percent. On the other hand, the effect of one percent increase in other commodity prices on real exchange rate was -0.15 percent for the first period while it increased to -0.73 percent in the next period. These changes in the impacts of energy and other commodities prices on the real exchange rate are likely due to sharp increases in energy and other commodities prices that had not been experienced before.

Using quarterly data for three, four (and few cases for five) digit NAICS industries (about 80) in Canadian manufacturing sector for the years between 1992-2007, the output equations indicate that 53 of the 80 industries have positive estimates for real exchange rate which indicate the existence of the Dutch Disease. Three industries show zero estimates for this variable and for other industries, 24 out of the 80 industries, the estimated coefficients are negative. The negative coefficients can be explained by this justification that these industries are probably not exposed to foreign competition and have enough ability to set their own prices. In fact, these industries cater for the home market as a result of trade protection or have monopolistic price-setting powers in their markets and, therefore, they may benefit from the rise in home demand as a result of oil boom.

Corresponding to the estimations of the elasticity of output with respect to real exchange rate, we have calculated the Dutch Disease effect in each industry (the effect of one percent change in energy prices on the output of each industry) using the elasticity of real exchange rate with respect to energy prices obtained from the exchange rate equation. 53 of the 80 industries experience decrease in their output as a result of increase in energy prices with the elasticity of -0.18 in average (after control for all major determinants including the role of energy as an input). This reaction is zero for three industries and is positive for 24 industries with the elasticity of 0.21 in average. While the average of the (long-run) Dutch Disease elasticity for the whole sample is -0.06, this elasticity tends to be concentrated between -0.30 and 0.10 in a way that about 75 percent of industries are in this range.

Based on the simulation results, among the industries that suffer from Dutch Disease (53 industries), each industry could experience more annual output growth by 0.93 percent on average if energy price remained at its level in 1992. However, this change would substantially vary across industries. On the other hand, among the industries that benefit from the oil boom (24 industries), each industry would experience less annual growth by 1.07 percent on average if energy price remained unchanged. Based on the results for whole sample, each industry could experience more annual output growth by 0.30 percent on average, although it varies substantially across industries. Considering that the average of annual industrial production growth has been 2.8 percent for 1992-2007, the simulation results imply that the annual output growth of each industry has decreased by about 11 percent on average as a result of the oil boom during this time period.

In summary, the results indicate that Leather [316], Clothing [315], and Textile mills [313] industries suffer severely from the Dutch Disease (their long run elasticities are around -0.35) and to a lesser extent, this negative effect is observed in Petroleum [324], Electrical equipment [335] and Furniture industries [337] (their long run elasticities are around -0.20). Food [311], Beverage [312], Transportation equipment [336] and Miscellaneous [339] industries suffer significantly from the Dutch Disease . On the other hand, it seems that industries like Printing [323] and Chemical [327] may benefit from Dutch Disease phenomenon (their long run elasticities are around 0.20). These results imply that the government should not be worry too much about the potential harmful effects that Dutch Disease might have on the Canadian economy in terms of lower innovation and therefore, permanently lower rates of growth. The reason is that the Dutch Disease effect is beneficial for some industries like Chemical and Printing and is insignificant for some other industries. More importantly, although some industries like Leather, Clothing, and Textile industries suffer severely from Dutch Disease, the general perception is that these ones should not be the significant sources of innovation. The only concern is about the Electrical equipment and Transportation equipment industries that suffer significantly from Dutch Disease and are expected to be the potential sources of innovation.

In general, the focus of this study was to examine whether Canadian industries have experienced the Dutch Disease or not. While the findings of this study show some evidence of Dutch Disease in Canadian economy (at least in some industries), it seems future researches should more investigate what Canada can do to immunize its economy against this disease. This issue would be very important if we note to this fact that the structure of the Canadian government would make replicating the experienced policies in other countries relatively difficult. In Canada, royalties on resource revenues are within provincial jurisdiction and therefore it might not be feasible to obtain a coordinated response from all levels of government.

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APPENDICES

Appendix A

Tests Results for Structural Change and Unit Root

Gregory and Hansen (1996) provide a residual-based test for cointegration in models with regime shifts. This test has the null of no cointegration while allows for a single break of unknown timing in the intercept and/or slope coefficients. In our case, the model with structural breaks is estimated by OLS as follows:

$$\begin{aligned} &log(re_t) = c_l + dum + \theta_{en}\, log(stben_t \times p_t^{en}) + \theta_{endum}\,(dum \times log(stben_t \times p_t^{en}))+ \\ &\theta_{oc}\, log(stboc_t \times p_t^{oc}) + \theta_{ocdum}\,(dum \times log(stboc_t \times p_t^{oc})) + \theta_{prodiff}\, prodiff_t + \varepsilon_t'' \end{aligned} \tag{A.1}$$

The ADF test statistic is calculated in the regression of $\triangle\hat{\varepsilon''}_t$ on $\hat{\varepsilon''}_{t-1}$ and lagged first differences. The t-ratio corresponding to the lagged residual is the statistic of interest. The break date is chosen such that the value of the test statistic is minimized. The search for the break is restricted to [0.15, 0.85] of the original sample. Thus, a number of dummy variables corresponding to different dates of break (from the second quarter 1994 to the second quarter 2005) are constructed and are employed in the estimation of the above equation. The results of this procedure indicate that the ADF test statistics corresponding to the last quarter 2003 is minimum among the others. Therefore the last quarter 2003 is chosen as the break point.

Table A.1: Z-A Unit Root Test Statistics and Critical Values for Data in RER Equation

Variable	**Z-A**	**C.V. 5%**	**C.V. 1%**
log(Real Exchange Rate)	-4.31	-5.08	-5.57
log(Real Energy Prices $\times$ $stben_t$**)**	-4.51	-5.08	-5.57
log(Real Other Commodity Prices $\times$ $stboc_t$**)**	-3.45	-5.08	-5.57
Interest Rate Differential	-2.74	-5.08	-5.57
Net Foreign Assets	-3.53	-5.08	-5.57
Productivity Differential	-5.09	-5.08	-5.57

The Zivot-Andrews test (1992) is a unit root test for a time series which allows for one structural break in the series, which may appear in intercept, trend or both. In this test, various criteria for detecting the structural break are supported. The Z-A test statistics and critical values reported in Table A.1 are for the case where test allows for structural break in both intercept and trend. Moreover, the lag length has been chosen based on the AIC.

Table A.2: ADF Unit Root Test Statistics and Critical Values for Data in RER Equation

Variable	ADF	C.V. 10%	C.V. 5%	C.V. 1%
log(Real Exchange Rate)	-0.40	-4.10	-3.48	-3.16
log(Real Energy Prices $\times$ $stben_t$**)**	-3.44	-4.10	-3.48	-3.16
log(Real Other Commodity Prices $\times$ $stboc_t$**)**	-1.62	-4.10	-3.48	-3.16
Interest Rate Differential	-1.97	-4.10	-3.48	-3.16
Net Foreign Assets	-2.58	-4.10	-3.48	-3.16
Productivity Differential	-4.25	-4.10	-3.48	-3.16

Note: ADF is specified with intercept and trend.

Table A.3: Real Exchange Rate Equation: First Difference Model

Variable	Estimates	t-Statistic
$\triangle$(**log(Energy Prices**$\times$ $stben$))	-0.10	-4.07
$\triangle$ **(log(Other Commodity Prices** $\times$ $stboc$))	-0.14	-3.02
$\triangle$ **Interest Rate Differential**	-1.10	-2.14
$\triangle$ **Net Foreign Assets**	0.07	2.68
$\triangle$ **First Lag of Dep. Var.**	0.41	3.32
$\triangle$ **Second Lag of Dep. Var.**	-0.13	-1.02
$\triangle$ **Third Lag of Dep. Var.**	0.27	2.36
R-squared	0.49	
Number of observations	61	

Note: All coefficients are interpreted as percentage.

Based on these results, one percent increase in energy prices leads to contemporaneous appreciation of the Canadian real exchange rate by 0.10 percent and it increases to 0.22 percent after three quarters ($0.22= \frac{0.10}{1-0.55}$) where 0.55 is the summation of the lags of dependent variable). On the other hand, one percent increase in other commodities prices leads to contemporaneous appreciation of the Canadian real exchange rate by 0.14 percent and it increases to 0.31 percent after three quarters.

Table A.4: ADF Test Statistics and Critical Values for Data and Residuals

Industry	Cdn Output	U.S. Output	R. INF. R.	Residual	10%	5%	1%	P-Value
311	-2.83	-1.22	-5.38	-3.4	-4.37	-4.75	-5.32	0.463
3111	-1.12	-2.73	-4.11	-5.57	-5.46	-5.86	-6.79	0.088
3112	-1.79	-2.87	-3.38	-4.29	-4.59	-5.14	-6.26	0.145
3113	-2.7	-2.41	-6.3	-4.34	-4.59	-5.28	-6.01	0.141
3114	-2.14	-1.75	-5.64	-4.49	-4.50	-4.83	-5.65	0.105
3115	-2.07	1.07	-4.72	-4.48	-4.45	-4.74	-5.40	0.092
3118	-2.08	-2.23	-4.53	-3.92	-4.73	-5.23	-6.12	0.315
3121	-3.53	-1.41	-5.69	-4.8	-4.42	-4.73	-5.26	0.038
31211	-2.7	-1.68	-6.33	-3.68	-4.14	-4.66	-6.01	0.189
313	-1	-2.45	-6.52	-4.19	-4.51	-4.82	-5.64	0.164
315	1.01	-2.11	-4.66	-3.98	-4.51	-4.88	-5.87	0.260
316	-2.15	-2.54	-4.83	-3.04	-4.00	-4.32	-5.67	0.324
3169	1.78	-1.68	-4.52	-4.47	-4.82	-5.33	-6.21	0.159
321	0.91	-2.45	-6.37	-3.05	-4.07	-4.57	-5.47	0.359
3211	1.62	-2.15	-7.45	-2.63	-4.51	-4.82	-5.32	0.683
3212	-0.51	-1.9	-5.16	-3.68	-4.42	-4.90	-6.05	0.285
3219	0.06	-2.16	-6.81	-2.8	-4.54	-5.01	-5.78	0.691
322	-0.78	-1.81	-5.84	-3.35	-4.13	-4.48	-5.56	0.307
32212	-1.86	-1.6	-5.51	-4.19	-4.63	-5.19	-5.93	0.184
3222	-0.66	-1.91	-5.39	-2.97	-3.98	-4.35	-5.07	0.358
32311	-2.05	-2.39	-5.99	-4.49	-4.95	-5.21	-5.87	0.197
32312	-2.59	-2.65	-6.39	-3.63	-3.94	-4.32	-5.12	0.166
324	-1.91	-1.59	-5.8	-5.96	-4.88	-5.40	-6.79	0.027
325	-0.96	1.42	-5.78	-4.76	-4.52	-4.88	-5.51	0.069
3251	-0.86	0.01	-5.33	-6.07	-4.62	-5.05	-5.93	0.008
3253	-2.58	-1.48	-5.59	-4.73	-4.56	-4.99	-5.81	0.079
3254	-2.45	-1.52	-5.28	-4.12	-4.91	-5.45	-6.79	0.255
3255	-3.02	-2.76	-5.35	-3.58	-4.08	-4.68	-5.83	0.203
3256	-0.28	1.53	-7.47	-5.53	-5.04	-5.42	-6.36	0.046
326	0.78	-2.02	-7.16	-2.98	-4.65	-4.96	-5.68	0.602
3261	0.39	-2.04	-7.45	-3.73	-4.74	-5.08	-5.68	0.315
3262	-1.12	-2.01	-5.3	-2.97	-4.13	-4.36	-4.94	0.357
327	-2.87	-1.91	-5.72	-5.02	-5.17	-5.64	-6.53	0.122
3272	-2.7	-2.63	-5.41	-5.15	-4.93	-5.12	-5.51	0.046
3273	-3.48	-2.16	-5.73	-5.46	-4.98	-5.28	-5.99	0.038
3274	-2.22	-2.11	-5.07	-4.5	-5.05	-5.53	-5.39	0.215
331	-0.94	-2.33	-5.21	-4.4	-4.75	-5.31	-6.17	0.137
3311	-3.06	-1.51	-5.12	-5.3	-5.19	-5.55	-6.50	0.088
3312	-2.5	-1.58	-6.58	-4.34	-4.33	-4.69	-5.45	0.099
3313	-1.32	0.08	-7.34	-4.72	-5.34	-5.77	-6.24	0.229
3314	-1.92	-2.19	-4.49	-4.47	-5.06	-5.61	-6.41	0.218
3315	-1.41	-2.74	-6.91	-4.05	-4.65	-5.09	-6.01	0.238
332	-1.52	-3.16	-5.86	-5.48	-5.14	-5.55	-6.35	0.061
3321	-2.28	-2.55	-6.32	-4.93	-4.52	-4.85	-5.73	0.045
3322	-2.49	-3.15	-5.54	-4.50	-4.5	-4.91	-5.87	0.100
3323	-2.05	-3.15	-7.43	-5.88	-5.06	-5.45	-6.28	0.030
3324	-1.39	-2.44	-6.45	-4.88	-5.01	-5.40	-6.42	0.129

Table A.4: Continued

Industry	Cdn Output	U.S. Output	R. INF. R.	Residual	10%	5%	1%	P-Value
3325	-0.22	-2.24	-7.25	-4.32	-4.96	-5.33	-6.39	0.214
3326	-1.65	-2.73	-5.12	-4.11	-4.67	-5.12	-6.00	0.182
3327	-2.22	-2.69	-6.47	-5.01	-4.82	-5.41	-6.25	0.079
3328	-1.84	-1.42	-4.77	-5.96	-5.09	-5.56	-6.37	0.022
3329	-2.68	-2.38	-5.74	-4.2	-4.96	-5.50	-6.34	0.255
333	-1.8	-2.33	-5.67	-3.92	-4.61	-4.91	-6.23	0.223
33311	-3.77	-2.62	-7.2	-3.24	-4.13	-4.46	-5.35	0.367
33312	-1.71	-2.19	-4.87	-4.27	-4.43	-4.82	-5.53	0.135
3332	-2.72	-2.54	-6.5	-5.22	-5.21	-5.66	-6.39	0.099
3333	-1.7	-2.96	-3.93	-5.8	-5.39	-5.64	-6.68	0.054
3334	-2.49	-2.86	-4.62	-5.94	-5.16	-5.59	-6.87	0.033
3335	-3.11	-1.92	-4.54	-5.05	-4.98	-2.30	-6.27	0.094
3336	-2.26	-1.96	-4.76	-4.98	-5.11	-5.48	-6.18	0.129
334	-3.15	-2.22	-3.81	-4.39	-4.65	-4.85	-5.33	0.147
3341	-0.83	-0.55	-3.6	-4.13	-4.96	-5.29	-6.05	0.286
3342	-2.23	-2.43	-3.66	-4.15	-4.55	-4.86	-5.62	0.199
3344	-1.76	-2.66	-4.02	-5.61	-5.17	-5.66	-6.16	0.054
3345	-3.43	0.48	-4.77	-4.77	-5.12	-5.64	-6.55	0.152
3346	-2.22	-2.69	-6.47	-4.1	-4.86	-5.38	-6.17	0.256
3351	-2.07	-2.74	-6.38	-4.48	-4.67	-5.09	-6.08	0.145
3352	-0.76	-1.31	-6.77	-4.82	-4.84	-5.41	-6.16	0.103
3353	-1.66	-3.06	-8.88	-6.29	-4.98	-5.32	-6.10	0.009
336	-0.87	-3.1	-4.34	-5.48	-5.02	-5.49	-6.42	0.051
3361	-1.72	-1.34	-3.77	-4.14	-4.82	-5.26	-6.15	0.224
3362	-1.63	-2.66	-6.94	-4.88	-5	-5.37	-6.24	0.105
3363	-0.05	-2.37	-6.01	-3.81	-4.56	-4.94	-5.59	0.237
3364	-2.87	-2.64	-8.11	-4.67	-5.41	-5.75	-6.47	0.327
3365	-2.32	-1.82	-4.94	-3.7	-4.74	-5.26	-6.25	0.295
3366	-2.04	-1.94	-4.53	-3.43	-4.19	-4.73	-6.53	0.261
337	-0.59	-2.45	-5.26	-4.77	-4.95	-5.37	-6.32	0.128
3371	-0.86	-1.96	-6.72	-4.01	-4.45	-4.91	-5.94	0.213
3372	-1.85	-2.07	-5.15	-3.97	-4.56	-4.68	-5.12	0.228
3379	-1.98	-2.57	-8.37	-4.03	-4.33	-4.61	-5.36	0.137
339	-3.18	-0.52	-4.19	-4.05	-5.09	-5.67	-6.15	0.322

Notes: All individual variables have been considered in logarithm form, except for relative inflation rate.

ADF test statistics for GDP, Real Exchange Rate, Government Expenditures and Interest Rate (all in logarithm form) are -3.14, 0.28, -1.12 and -2.71 respectively.

Columns 2-4 show the ADF test statistics for Canadian and U.S. outputs and relative inflation rate in Canada.

Column 5 shows the ADF test statistics for the Residuals obtained from the long-run relationships.

Columns 6-8 show the bootstrapped critical values to reject unit roots in residuals at 10, 5 and 1 percent levels.

Column 9 shows P-values related to the ADF test statistics for Residuals.

Critical values to reject unit roots in individual series at 10, 5 and 1 percent levels are -3.17, -3.48, and -4.12.

Appendix B

Data Sources

Data Sources for Real Exchange Rate Equation

re: Real Canadian per U.S. dollar exchange rate. Quarterly average of monthly spot rate (Table 176-0049 of CANSIM: Foreign exchange rates) multiplied by the ratio of U.S. to Canada implicit GDP deflator. U.S. and Canada deflators are indexed to 2002=100 and are obtained from Federal Reserve Bank of Dallas and Table 383-0008 of CANSIM respectively.

p^{en}: Real energy price index. Energy price index is obtained from Table 176-0001 of CANSIM: Commodity price index, United States dollar terms (82-90=100). The index is deflated by U.S. GDP deflator obtained from Federal Reserve Bank of Dallas.

p^{oc}: Real other commodities price index. Other commodities price index is obtained from Table 176-0001 of CANSIM: Commodity price index, United Sates dollar terms (82-90=100). The other commodities price index is made real using U.S. GDP deflator obtained from Federal Reserve Bank of Dallas.

stben: The energy trade balance as a ratio of the total commodities trade balance. Table 228-0041 of CANSIM: Merchandise imports and exports.

stboc: The other commodities trade balance as a ratio of the total commodities trade balance. Table 228-0041 of CANSIM: Merchandise imports and exports.

NFA: Net foreign assets. Table 376-0055 of CANSIM: International investment position, quarterly (dollars x 1,000,000,000).

$idiff$: Canada-U.S. nominal interest rate differential. Canadian three-month prime corporate paper rate from CANSIM (Table 176-00431: Financial market statistics, last Wednesday) and U.S. 90 day AA non-financial commercial paper from the Federal Reserve Board.

$prodiff$: Canada-U.S. labour productivity differential defined as the difference in labour productivity growth between Canada and US. Canadian labour productivity index is from Table 383-0012 of CANSIM (Indexes of labour productivity and related variables, 2002=100) and the U.S. labour productivity index is from Bureau of labour Statistics (2002=100).

Data Sources for Sectoral Output Equations

$Y_{k,t}^{CAN}$: The Canadian production in each industry. Table 379-0027 of CANSIM: Gross Domestic Product (GDP) by North American Industry Classification System (NAICS), computed quarterly figures (dollars x 1,000,000), Seasonally adjusted, 2002 Constant Prices.

$Y_{k,t}^{US}$: The U.S. production in each industry: reported by U.S. Bureau of Labor Statistics (2002=100), Seasonally adjusted.

$RINFR_{k,t}^{CAN}$: The Canadian expected relative inflation rate in each industry which is constructed using Producer Price Index in each industry (Table 329-0038 Industry price indexes, by North American Industry Classification System (NAICS), Seasonally adjusted) and Implicit Price Deflator in Canada (Table 383-0008 Indexes of labour productivity, unit labour cost and related variables, Seasonally adjusted).

GDP_t^{CAN}: Non-energy Gross Domestic Product in Canada (Total GDP minus the Energy Sector: Table 379-0027 Gross Domestic Product (GDP) by North American Industry Classification System (NAICS), computed quarterly figures (dollars x 1,000,000) (2002 constant prices), Seasonally adjusted.

$GOVEX_t^{CAN}$: Canadian government expenditures as the summation of the expenditures by local and federal governments reported in Tables 380-0035 (Income and expenditure subsector accounts, local government, quarterly, Seasonally adjusted) and 380-0034 (Income and expenditure sub-sector accounts, federal government, quarterly, Seasonally adjusted) of CANSIM respectively.

$INTR_t^{CAN}$: Interest rate in Canada. Since we are interested in the effect of monetary policy and Bank of Canada can directly control the target for the overnight rate, we choose "overnight money market financing, 7 day average" as the data for interest rate (Table 176-0043 of CANSIM: Financial market statistics).

Chapter 2

Exchange Rate Pass-Through into Producer Prices: Literature Review and Developing a Relatively more General Theoretical Framework

2.1 Introduction

Exchange rate volatility between the US and Canadian dollars has dramatically increased in the past few years. Ongoing large U.S. trade and fiscal deficits, the slow down in the dollarization of trade, and the global financial crisis, coupled with impacts of increasingly volatile oil, metals, and grain prices on the Canadian dollar as a commodity currency, suggest that Canada/U.S exchange rate could continue to be volatile for the foreseeable future.

As statistics show, the United States is Canada's most important trading partner. In 2007, 76 percent of all Canadian exports were shipped to the U.S., and the U.S. supplied 65 percent of Canadian merchandise imports. Therefore, the Canada/U.S. exchange rate is a key economic factor that affects the prosperity of the Canadian economy, particularly the manufacturing sector, through changes in Canadian output and input prices. The significant appreciation/depreciation of the Canadian dollar in recent years has created great interest in the effects of these changes on the Canadian economy. It seems examining the exchange rate pass-through (ERPT), which indicates the extent that Canadian output prices are affected by the exchange rate changes, can shed some light in this issue.

Exchange rate pass-through (ERPT) is defined as the percentage change in local currency prices of tradable goods as a result of one percent change in the exchange rate between the home country and its trading partner. Complete ERPT refers to a one-to-one relationship between local prices and exchange rate changes while partial ERPT refers to a less than one-to-one response. The rate of the ERPT has important implications for the volatility of the real exchange rate as well as the effectiveness of the trade and monetary policies. Moreover, the exchange rate pass-through estimations help us to identify and understand those markets which are more at risk from large variations in exchange rates, which in turn can help in designing appropriate policies. As a result, the relationship between exchange rate and good prices has been examined by many researchers particularly after the move from fixed to floating exchange rate system (May 1970).[1] The purpose of this study is to model and estimate the extent of exchange rate pass-through to domestic producer prices for three, four and (few cases of) five-digit NAICS industries in the Canadian manufacturing sector. Then, in the next stage, it identifies the factors explaining the pass-through variation across industries.

To examine the theoretical and empirical aspects of exchange rate pass-through and its determinants, the study is organized in two separate but related papers. This chapter, as the second paper of the thesis, presents a literature review and contributes to the literature by developing a relatively more general theoretical framework. The next chapter, as the third paper of the thesis, provides the estimations of the exchange rate pass-through elasticities and their determinants in Canadian manufacturing industries. In this chapter which is a theoretical paper on the ERPT, after the introduction, section 2.2 is allocated to the review of the theoretical and empirical literature on exchange rate pass-through. In addition to a discussion about the law of one price (LOP)[2] which predicts that exchange rate pass-through should be equal to one, the theoretical literature review tries to explain why exchange rate pass- through could be less than one. Some factors such as market structure, different demand elasticities in the import and export markets, multinational enterprises, non-tariff barriers and pricing to market (PTM) are discussed as the related reasons. In the review of empirical studies, the major empirical studies are discussed particularly in terms of their model structure, contribution and weakness. In addition to providing a reference to compare our findings, this review helps us in considering the related variables and choosing

[1] The detailed discussion on these studies has been provided in literature review.

[2] Law of one-price states that, in the long run, traded commodity prices in two countries must be the same, after adjustment for transaction costs.

the appropriate measures for them.

The literature suggests that the estimation of ERPT for manufacturing industries and primary products (such as agricultural products) requires two different theoretical frameworks and therefore model specifications. Primary products are goods which the products of different countries are close to identical, or near-perfect substitutes, and therefore the LOP could be expected but this does not hold for manufactured products.

The theoretical framework for estimation of the ERPT in manufacturing industries is presented in Section 2.3. We contribute to the literature by developing a relatively more general model which is able to show all the major determinants of exchange rate pass-through together, while the previous studies have only analyzed the role of one or some of these factors. We consider the domestic market for differentiated products, which belong to a well-defined industry category but imperfect substitutes for each other in the eyes of consumers, such as automobiles. We assume that some of the varieties are produced domestically, while others are imported. We also assume that the individual firm is sufficiently large to affect industry price and firms respond to changes in industry price. Moreover, it is assumed that the marginal cost is increasing and is affected by the wage rate and the price of the intermediate materials (which are considered as the tradable inputs) in addition to the production level. Using first order conditions in the demand and supply sides of the market and equilibrium conditions, the domestic producer price for each specific industry is derived as a positive function of demand pressure in domestic market, the wage rates in home and foreign countries, the price of the intermediate materials in home and foreign countries, and the nominal exchange rate defined as the number of units of domestic currency per unit of foreign currency.

By taking a total differentiation of the first order conditions and solving the model for exchange rate pass-through, it is shown that exchange rate pass-through is between zero and one. It is also shown that there is a positive relationship between the magnitude of the ERPT to the domestic producer price and the elasticity of domestic marginal cost with respect to exchange rate, and the domestic firms' market share, while there is a negative relationship between the magnitude of the ERPT and the elasticity of marginal cost with respect to output. The degree of substitutability among the variants is another determinant of the ERPT but its sign is not theoretically clear and remains as an empirical question.

The provided theoretical framework will be applied in Chapter 3 as the base for estimation of the exchange rate pass-through and its determinants in Canadian manufacturing industries.

Finally, a summary and conclusions of this chapter is presented in section 2.4.

2.2 Review of Exchange Rate Pass-Through Literature

Interest in the question of exchange rate pass-through[1] goes back to the fist half of the nineteenth century when Ricardo and other economists analyzed the effects of exchange rate movements on the export and import prices based on the law of one price (LOP) and the purchasing power parity doctrine (PPP). But this interest grew following the move from fixed to floating exchange rates in the early 1970s. Since then a wide range of models have been developed to explain the varying pass-through experiences in different countries and in different sectors of the economy.

Menon (1995), and Goldberg and Knetter (1997) have presented two insightful reviews of the exchange rate pass-through literature, which provide some guidelines to this literature review. The literature review in this section includes the most important studies in this area including the important ones discussed in Menon (1995), and Goldberg and Knetter (1997) as well as the studies completed since 1997.

Since this paper is focused on the exchange rate pass-through to domestic producer prices at the sector level, the macroeconomic perspective of exchange rate pass-though, such as the effect of exchange rate movements on the balance of payments and domestic inflation are not included in this literature review. However, the theoretical and empirical studies examining the exchange rate pass-through to export or import prices in microeconomic level data are discussed because the reasons of incomplete pass-through that are analyzed in those studies, such as trade barriers, transactions and transportation costs, market power, among others, are also the reasons of incomplete pass-through to domestic prices.

The literature review is presented in two major parts: the theoretical and empirical parts. In the theoretical literature review, in addition to discussion about the law of one price (LOP) which predicts that exchange rate pass-through should be equal to one, we try to review the studies that explain why exchange rate pass-through could be less than one. Some factors such as market structure, different demand elasticities in the import and export markets, multinational enterprises, non-tariff barriers and pricing to market (PTM) are discussed as the related reasons. In the review of empirical studies, the major empirical studies are discussed particularly in terms of their model structure, contribution and weakness. In addition to providing a reference to compare our findings, this review helps us in considering the related

[1]The extent to which exchange rate changes are reflected in the price of exports (dominated in foreign currency) or imports (dominated in local currency) or domestic producer price is known as exchange rate pass-through.

variables and choosing the appropriate measures for them.

2.2.1 Theoretical Models of Exchange Rate Pass-Through

2.2.1.1 Law of One Price and Purchasing Power Parity Doctrines

In most of the theoretical models developed prior to the early 1970s, it was commonly assumed that there is complete exchange rate pass-through to import or export prices. The best known of such theoretical models is the law of one price (LOP) or purchasing power parity theory (PPP). The relative version of the LOP states that the prices of identical traded commodity (in common currency) in two countries must be the same, after adjustment for transaction costs. If the LOP held for all products between two countries then the purchasing power parity (PPP) theory of exchange rates (relative version) would hold between these two countries. In fact, the relative LOP means that although costs of transportation or resale (such as trade barriers) preclude price equalization (the absolute version of the LOP), there should be a stable price differential across two markets. In this case, we have:

$$\text{The relative LOP} \qquad p_i = \alpha E p_i^* \tag{2.1}$$

$$\text{The relative PPP} \qquad P = \alpha E P^* \tag{2.2}$$

where p denote the home currency price in country H, p^* the home currency price in country F, E the exchange rate of H's currency per unit of F's, P and P^* price levels in countries H and F. ($\alpha \times 100$) is the home currency price (level) as a percentage of the foreign. If α remains constant over time, then common currency prices for a particular product (or market basket) change in the same way over time in two countries, and the relative LOP (PPP) holds.

The following generic regression model, which is a test of arbitrage condition, has been used in empirical research on the LOP.

$$\log(p_t) = \alpha + \delta \log(X_t) + \gamma \log(E_t) + \varepsilon_t \tag{2.3}$$

X includes a measure of price for the same product in country F, say p^*. Distinctions among papers then center on the selection of transactions for which prices are measured and the degree to which they satisfy the identical goods assumption. By considering that the prices are measured in different currency units, the relative LOP stated in equation 2.1 implies that

γ in equation 2.3 should be equal to one (complete exchange rate pass-through). If the price measures are already in units of the same currency, then the LOP implies that γ=0.

Some of the important studies on the validity of the LOP (complete pass-through) have been summarized in Table 2.1. The general result is that although the LOP is confirmed for primary commodities[1] (Isard, 1977), which are the cases where the products of different countries are close to identical, or near-perfect substitutes, the LOP (complete pass-through) has been rejected for a variety of industrial products and countries, using a variety of data sources and empirical methods (Rogoff, 1996). Therefore, many theoretical models have been developed to explain incomplete exchange rate pass-through. Some factors such as market structure, the size of the market, different demand elasticities in the import and export markets, multinational enterprises, non-tariff barriers and pricing to market (PTM) have been mentioned as the related reasons. We now review some of these models.

[1]This may not be the case when sellers of primary commodities have monopoly power and/or enter into long-term marketing agreements with their customers.

Table 2.1: Selected Empirical Studies on Law of One Price

Author(s) of Study	Data	Method and Model	Findings
Kravis and Lipesy (1977)	Study ratio of U.S export prices for machinery and transport equipment by country of destination (Germany and U.K.) to U.S. domestic prices. Annual data from 1954 to 1974 are used.	Ratio of U.S export prices to U.S. domestic prices is regressed on exchange rate and its lag as well as relative (foreign to home) price movements and its lag as a means of summarizing relative cyclical conditions. This equation is estimated separately for Germany and U.K.	In German equation, exchange rate with one year lag is the only significant variable which rejects complete exchange rate pass-through. In U.K. equation, although relative rate of inflation is significant, the exchange rate is not statistically different from zero which supports complete exchange rate pass-through. The difference between the results of these two equations has been justified based on the economic performance of U.K. and Germany in this period.
Isard (1977)	Study ratio of U.S. import unit value by country of origin (Canada, Germany and Japan) to U.S. export unit value. Five commodity groups are considered: soaps, tires , wall paper, ceramic tile, and steel bars. Quarterly data from 1968 to 1975 are used.	The ratio of U.S. import unit value by country of origin (Canada, Germany and Japan) to U.S. export unit value is regressed on the exchange rate using OLS. Cochrane-Orcutt procedure is used to correct for serial correlation.	Deviations from the LOP are large and persistent. The coefficients of exchange rate in the German and Japanese cases are significantly different from zero. This suggests that substantial changes in exchange rates typically have substantial and persistent effects on the relative common currency prices of closely matched manufactures produced in different countries.

Table 2.1: Continued

Author(s) of Study	Data	Method and Model	Findings
Richardson (1978)	Study commodity arbitrage between the U.S. and Canada. 23 commodity groups at the 4 and 7-digit level of SIC are considered. Monthly data from 1965 to 1974 are used.	The growth rate of the domestic prices in Canada is regressed on the growth rates of the U.S. prices and the exchange rate using OLS. The growth rates of variables instead of their levels are applied to avoid problems arising from autocorrelation and lack of information on transaction costs.	(1) Commodity arbitrage does not take place for a majority of commodity classes. (2) When commodity arbitrage does take place, it is never perfect even for comparatively homogeneous commodity groups.
Ardeni (1989)	Examine the validity of LOP for wheat, wool, beef, sugar, tea, tin and zinc between each pair of these four countries: U.S., Canada, Australia and U.K. using export (import) prices adjusted for exchange rates. Quarterly data from 1965 to 1985 are used.	Co-integration approach is applied. The export (import) price of each commodity in one country is regressed on import (export) price of that commodity adjusted for exchange rates in another country. Then residual is tested for unit root.	The results show that exchange rates and commodity prices appear to be non-stationary but not co-integrated , thus showing a lack of empirical support for the LOP as a long-run relationship.

Table 2.1: Continued

Author(s) of Study	Data	Method and Model	Findings
Carter, Gray and Furtan (1990)	Study commodity arbitrage between the U.S. and Canada for three outputs (wheat, canola/soybeans, feeder steers) and five inputs (fat steers, fertilizer, pesticides, petroleum, and farm machinery) in agriculture sector. Input and output prices are paid and received prices by farmers respectively. Quarterly data from 1975 to 1988 are used.	Difference between the rate of changes in Canadian prices and the rate of changes in U.S. prices is regressed on a constant, the rate of changes in exchange rate and its two lags using OLS. In this specification, intercept term shows the constant growth rate of transaction costs.	The regression results support a contemporaneous LOP for canola and petroleum, one-lagged LOP for wheat, and two-lagged LOP for feeder steers, fat steers, and pesticides. There is essentially no pass-through for farm machinery.
Vinuya (2007)	Study price data (in U.S. dollar) on imported frozen shrimp as a product group in the European Union , Japan, and the United States to test the validity of LOP across these markets. He also examines specific prices for shrimp in disaggregated product categories up to ten digit HTS in well-identified wholesale market places across these countries to test LOP between each pair of specific market places. Monthly data from 1997 to 2005 are used.	Co-integration techniques are utilized. Multivariate Johansen Test for Co-integration between aggregated prices in U.S., E.U., and Japan (in logarithm form) is carried out. Moreover, to check the consistency of the results in the aggregated level, co-integration test is also carried out for prices in wholesale markets.	The results indicate that there are two co-integrating vectors for aggregated prices. However, the multivariate test for LOP was rejected for the system. There is evidence of co-integration in all possible combinations of the price series in the three wholesale markets. The hypothesis that the LOP prevails in the three markets was likewise supported. This outcome implies that LOP tests using aggregated price series might lead to incorrectly rejecting the hypothesis.

2.2.1.2 Incomplete Exchange Rate Pass-Through Models

The Elasticity Model The earliest attempts to interpret incomplete exchange rate pass-through use the elasticity approach which was elaborated by Branson (1972). By considering the log-linear demand and supply functions for an imported good, he derives the exchange rate pass-through to domestic prices as follows:

$$(\frac{\partial p_d}{p_d})/(\frac{\partial E}{E}) = (1 - \varepsilon_d/\varepsilon_s)^{-1}$$

where p_d represents the domestic currency price of the imported good, E shows the exchange rate (the foreign currency price of domestic currency) and ε_d and ε_s are the elasticities of demand and supply in importing country respectively. Based on this equation, the percentage change in the domestic currency price of imports as a result of an exchange rate change is determined by the elasticities of demand and supply. Perfectly elastic (inelastic) supply or perfectly inelastic (elastic) demand would mean complete (zero) pass-through. Krenin (1977) supports the elasticity explanations of pass-through. Although the elasticities can vary between countries and over time, Krenin made the following generalizations regarding pass-through: a small country is likely to experience a nearly complete pass-through because it is likely the case that it may face a high elastic supply of exports from its trading partners. A large country, on the other hand, is most likely to face an upward sloping export supply curve and therefore only a partial pass-through can be expected.

There are two major problems regarding the measurement of pass-through based solely on elasticities of demand and supply. First, this approach does not provide any information on the timing of the response of prices to exchange rate changes. Second, it ignores what lies behind the supply responses of producers in different countries (Venables, 1990). The supply response will depend on the details of the industrial organization and of the technology of the industry under study. Developments in the literature on imperfect competition and trade address both these issues which are examined in next sections.

Imperfect Competition in a Static Framework and Incomplete Pass-Through Several variants of imperfect market structure have been developed to justify incomplete exchange rate pass-through. An industry's market structure is indicated by following factors: (1) market share, (2) the degree of vertical integration, (3) the extent to which firms are diversified across product lines, (4) the height of the entry barriers, (5) the extent of product differentiation, and (6) the degree of buyer concentration. It is clear that these aspects of market structure are all related to the price elasticities of supply and demand. Among the papers studying pass-through from microeconomic perspectives, the studies of Dornbusch (1987), Fisher (1989), Feinberg (1989), Feenstra (1989), Sibert (1992), and Yang (1997) which emphasize the roles of market power and the imperfect substitutability of comparable domestic and foreign products, are widely accepted as the benchmark.

Dornbusch (1987) develops four theoretical models and includes some empirical evidence to show that the extent of domestic price adjustment depends on the convexity of demand schedules, substitutability of foreign and domestic products, import penetration and market structure. First, he assumes perfect substitution between domestic and foreign suppliers in a Cournot model. It is assumed that firms price separately for home and foreign markets. Therefore, in this setting, the nature of oligopoly is emphasized and the market structure, namely the ratio of the number of foreign firms to total firms and the convexity of demand curve, are the key parameters that explain the incomplete pass-through. In contrast, in second (the Dixit-Stiglitz (1977) model) and third (the extended Dixit-Stiglitz model) models, the imperfect substitution between domestic and foreign products is considered. The extended Dixit-Stiglitz model develops the Dixit-Stiglitz model by considering strategic interaction among firms, namely introducing a conjectural variation, in the same structure of differentiated products. Finally, again emphasizing product differentiation, he presents another model where consumer tastes are assumed to be uniformly spread over the unit circle. In all provided models, Dornbusch shows that the exchange rate pass-through could be less than one.

In contrast to Dornbusch's quantity competition setting, Fisher (1989) presents a partial equilibrium model, which uses price as the firm's choice variable and employs a Bayesian Nash equilibrium concept to address the question of how market concentration affects the relationship between commodity and currency prices. It is assumed that foreign firms produce for both home and export markets and cannot price discriminate. The model has four important elements. First, it incorporates the idea that producers set prices in anticipation of exchange rate changes. This price setting occurs because under the floating exchange rate regime, it would be expensive for most manufacturers in industrialized countries to change their offer price with every movement of the value of foreign exchange. Second, by emphasizing the strategic interdependence of producers' decisions, this model shows that market structure has an influence on exchange rate pass-through. Specially it is shown that exchange rate pass-through is higher if the home market is monopolistic or if the foreign market is competitive. Third, the model shows that the effects of exchange rate changes are quite different in the short run and the long run. Fourth, it captures the notion that pass-through is different under a regime of fixed exchange rates from the regime of floating rates.

Sibert (1992) extends the Cournot model provided in Dombusch's analysis and examines the effects that different degrees of collusion and market shares of foreign firms have on pass-through. Sibert develops a partial equilibrium model in which exchange rate is taken as exogenous, markets are separated, a homogenous good is produced by both home and foreign firms, and firms face general demand and linear cost curves. This model shows that if there is no home production and firms are price takers, there is a one for-one response of import prices to exchange rates. However, in this model, if firms are not price takers, Cournot competition or joint profit maximization by foreign firms may lead to the case that exchange rate pass-through be greater or less than unity. Thus, less competition need not always lead to lower pass-through. In the case of linear demand, when both home and foreign firms operate in the market, the model shows a greater pass-through because of more competition. Under Cournot competition and profit maximizing behaviour, the model indicates a positive relationship between the pass-though and the number of foreign firms.

In contrast, Feinberg (1989) extends the second model provided in Dombusch's analysis, which is based on the assumption that domestic goods and imports are imperfect substitutes in use, to consider the implications of imported inputs as well as oligopolistic domestic market structures in determining the relationship between movements in exchange rate and domestic prices. In this model, a composite commodity is defined as a constant elasticity of substitution (CES) function of the domestic goods and imports. Demands for domestic goods and imports are then derived demands, depending on demand for composite good and relative prices. The sensitivity of relative consumption (imports to domestic products) to changes in relative prices is measured by the constant trade substitution elasticity. As an oligopolistic structure in provision of the domestic goods, Feinberg uses a standard quantity-setting conjectural variations model. Moreover, because an important source of transmission of international shocks is through the use of imported inputs, Feinberg assumes that the technology in the domestic goods sector is captured by a fixed-coefficients linearly-homogeneous production function with the only two arguments: domestic and foreign input aggregates, and the ratio of foreign to total inputs varying by industry. Finally he allows the pass-through from exchange rates to import prices to be less than complete (without providing any explicit model to show the supply of the imported good to the domestic market). Based on these assumptions and first order conditions of profit maximization of domestic firms, it is shown that there is a positive relationship between exchange rate pass-through and the domestic currency share of imported inputs in cost, the pass-through into import prices, the degree of substitutability between imports and domestic products, and each firm's conjecture (as to the increase in market output due to a one unit increase in its own output) while the number of domestic firms in the market decreases the exchange rate pass-through.

Feenstra (1989), which aims to test whether the long-run pass-through of tariffs and exchange rates are identical, provides a theoretical models on determinants of exchange rate pass-through. In contrast to previous studies, the assumption of constant marginal costs is relaxed and it is shown that the exchange rate pass-through to import prices is mainly affected by the underlying cost functions as well as demand schedules. In this model, it is assumed that the imported and domestic varieties of a differentiated product are competing in domestic market. Assuming that the differentiated product is weakly separable from other goods in the consumer's utility function, import demand is considered as a function of the home currency price of the imported and domestic varieties of a differentiated product as well as income or expenditure on all varieties. The foreign firm maximizes expected profits in its own currency with respect to the home currency price of its product, treating the home currency price of the domestic varieties and income as exogenous. From first order conditions, the home currency price of imports is derived as a function of foreign factor prices in the domestic currency, the home currency price of the domestic varieties and income. Then, totally differentiating the first order condition yields the pass-through elasticity (the change in the import price due to a change in the expected exchange rate or foreign factor prices) as a function of first and second derivatives of cost function as well as price elasticity of demand in each specific price. It is shown that if the price elasticity of demand is negative and the cost function is convex, the pass-through elasticity is between zero and one. On the other hand, positive price elasticity of demand and concave cost function leads to pass-through elasticity which is greater than one.

So far, we reviewed the base studies on the relationship between imperfect competition and incomplete exchange rate pass-through. But it seems there are some specific limitations in the reviewed studies. Except Feenstra, all have assumed that the marginal cost is constant. Although Fisher and Sibert model strategic interaction between foreign and domestic producers, it is done at the expense of treating imports and domestic goods as perfect substitutes. On the other hand, Feinberg and Feenstra have ignored the strategic interaction between foreign and domestic producers. In a more comprehensive study, Yang (1997) tries to address these issues. He provides a model with increasing marginal cost, strategic interaction and product differentiation features. This model, which our theoretical framework will be based on[1] and will be explained in detail in the related section, predicts that the magnitude of exchange rate pass-through to import prices is positively related to the degree of product differentiation and inversely related to the elasticity of marginal cost with respect to output and the foreign firms' market share.

In addition to the specific limitations, there are several common limitations in the reviewed studies. First, these models do not consider the dynamic aspects of price adjustments in the sense that neither the actual nor the expected duration of the exchange rate change affect the extent of price adjustment. That is, the extent of exchange rate pass-through is independent of whether the exchange rate has just risen (decreased) or has been high (low) for a number of years. It is also insensitive to whether the current strength of the exchange rate is regarded as permanent or soon to be reversed. Second, they ignore the possibility of the change of market structure due to large exchange rate fluctuation, i.e. the hysteresis in exchange rate pass-through. Third, they omit the role of multinational firms and non-tariff barriers on trade. The following sections try to address these issues.

Imperfect Competition in a Dynamic Framework and Incomplete Pass-Through

Krugman (1986) provides some dynamic models to justify the phenomenon of pricing to market (PTM). In general, PTM means that import prices fall too little when a currency appreciates or in other words incomplete pass-through. However, this does not mean that PTM is present whenever import prices fail to fall in proportion to the exchange rate appreciation. For a large country, a less than proportional response of import prices to the exchange rate is not in general surprising, and not require an exotic explanation. When a currency appreciates, imports become cheaper in the domestic market and people will buy more; if this market is a significant share of world demand, this will drive up the world price of imports. Therefore, PTM is defined as the case where exchange rate pass-through to import prices is incomplete after accounting for any effect of the exchange rate on world prices of the

[1] Our theoretical framework differs from it in two aspects. First, this study provides a specific solution for exchange rate pass-through to domestic produce price rather than the foreign firm's price. Second and more importantly, input prices (wages, intermediate material prices) are included in the marginal cost function and their role in price determination and consequently the role of imported inputs in exchange rate pass-through determination, as our contribution, are examined.

imported goods. In addition to three static models (supply and demand, monopolistic price discrimination, and oligopoly), he provides two dynamic models of imperfect competition which offer possible rationalizations for pricing to market phenomenon when the change in exchange rate is either unanticipated or expected to reverse. The first of these models stresses the role of supply dynamics resulting from the costs of rapidly adjusting the marketing and distribution infrastructure needed to sell some imports. This model shows that in the case of a permanent appreciation the price would fall only gradually as the rate of delivery to destination market increases, and finally fall by the full amount of the appreciation in the long run. In the case of a temporary appreciation the price would fall more slowly from the start and might actually begin to rise before the exchange rate reversal.

The second model stresses the role of demand dynamics resulting from the need of firms to invest in reputation. The basic idea of this model is that a purchase of imported goods is a two-stage process. First, potential buyers must decide whether to put themselves in the market for a product. It is assumed that putting oneself into a market is costly, and will be done only if the price is expected to be sufficiently attractive. Second, those in the market must then decide whether in fact to purchase, and how much to buy. The effect of this two-stage process will be that demand depends not only on the actual price but on the price that customers expect to pay when they decide whether or not to put themselves in the market. The question then is how the expected price gets determined. In practice, the way this seems to happen is that firms cultivate a reputation over time for being in a certain price range. If the firm fails to honor its announcement, in future periods it will not be believed. Therefore, to keep this reputation, an unexpected appreciation or depreciation of exchange rate which is a cost shock for exporter will not be passed on the prices proportionally.

Froot and Klemperer (1989) investigate the pass-through from exchange rates to import prices by focusing on dynamic demand-side effects in an oligopolistic market. They provide a model in which firms' future demands depend on current market shares. Therefore, expected future exchange rates affect the value of current market share, and so affect current pricing strategies. They find theoretically, and provide some empirical evidence, that this type of intertemporal dependence implies that the magnitude and even the sign of the pass-through will depend on whether exchange rate changes are thought to be temporary or permanent. In response to a temporary appreciation of the dollar, for example, foreign exporters to the United States will reduce their dollar prices by less in this model than in the standard static oligopoly framework. This occurs because the appreciation increases the value of current, relative to future, dollar profits expressed in foreign currency. When the value of the dollar is temporarily high, foreign firms will find investments in market share less attractive, and will prefer instead to let their current profit margins grow. In fact, the expectation that the dollar will depreciate over time may erode the value of future profits so much that foreign firms could raise their dollar prices when the exchange rate appreciates. Permanent dollar appreciations, on the other hand, do not create such incentives to shift profits from tomorrow to today. Since foreigners' current and future costs (expressed in dollars) fall as the dollar undergoes permanent appreciation, foreign firms compete more vigorously, clearly driving current prices down. Indeed, prices may fall more than in a static oligopoly model.

Concerning the exchange rate pass-through to the domestic producer prices, Feinberg and Kaplan (1992) further explore the role of expected future exchange rate. By developing an index of real exchange rate expectations and using the U.S. data, they indicate that actual and expected future real exchange rates are seen to have opposite impacts on domestic price determination at the industry level. In contrast to an actual real dollar appreciation, an anticipated future real appreciation of the dollar actually raises the domestic producer price and the extent of this effect depends on the nature of substitutability between imports and domestic goods in each specific sector. The rational is that an anticipated future appreciation implies reduced future demand for the products of the domestic industry. This reduces the incentive for current period price moderation in pursuit of market share and future profits.

Tivig (1996) analyzes the issue of exchange rate pass-through using four variants of a two-period model for duopolistic competition in a market for differentiated products and constant marginal costs. Simple conditions for the occurrence of normal or perverse pass-through of a temporary exchange rate change are formulated for the case of perfect and imperfect capital mobility. These conditions are applied to reactions of current as well as future prices for both the imported and the domestic product. In an example with linear demand it is additionally shown that temporary exchange-rate fluctuations cause current as well as future price changes which do not necessarily point in the same direction.

Hysteresis and Incomplete Exchange Rate Pass-Through Although Menon (1995) argues that the dynamic and inter-temporal behaviour also underlies the "hysteresis" model in exchange rate pass-through, the latter distinguishes itself from the former with its distinctive assumptions and conclusion. Baldwin (1988) defines hysteresis as a situation in which the temporary shocks of exchange rate have effects that do not disappear as the shocks are removed. Baldwin is the earliest study that systematically models the hysteresis in exchange rate pass-through, where sunk costs and the size of the exchange rate shock are determining variables. In this model, the effects of large exchange rate shocks could be qualitatively different from the effects of small changes. Small shocks in exchange rate create no change in market structure; they have only temporary effects on price; that is, when the exchange rate returns to its original value, prices also return to their original levels. On the other hand, large exchange rate shocks can change market structure (defined in terms of the number of firms), which may have persistent real effects. In other words, temporary large exchange rate shocks may lead to hysteresis.

Baldwin uses a Cournot oligopoly framework with a homogenous good. A foreign firm can enter the domestic market only by incurring a sunk cost. To remain in the market, a fixed maintenance cost is required each period. The paper shows that in this case a temporary rise in the exchange rate, if sufficiently large, would induce foreign firms to enter the domestic market. Since the entry costs are sunk, not all of the new entrants exit when the exchange rate returns to its original level. After the over-valuation passes, the number of firms is still large, thus the post-shock price is permanently lower than the pre-shock price. Indeed, this persistent change in market structure leads to structural breaks in the estimated equation of exchange rate pass-through. In empirical part of the paper, he finds evidence that hysteresis has occurred in the U.S. in the 1980s.

The original sunk cost framework was further developed as the assumption of perfect foresight was relaxed by Dixit (1989) and Baldwin and Krugman (1988). Dixit's model is formulated in a perfectly competitive setting, in which the entry or exit to or from industry is associated with some sunk cost. Assuming that the real exchange rate follows a Brownian motion in continuous time, he parameterizes hysteresis in terms of the underlying volatility of the exchange rate and provides supportive theoretical results for hysteresis phenomenon in exchange rate pass-through to domestic prices. This model introduces the idea of an exchange rate band within which if the exchange rate moves, there will be no entry and exit of firms, and therefore exchange rate pass-through will be close to zero. Any movement of the exchange rate outside of the band can trigger entry or exit of firms, which changes market structure and in this phase the exchange rate pass-through will be different from zero. Baldwin and Krugman (1988) not only allow for a stochastic exchange rate to induce hysteresis, but also examine the feedback from entry and exit decisions to the exchange rate itself.

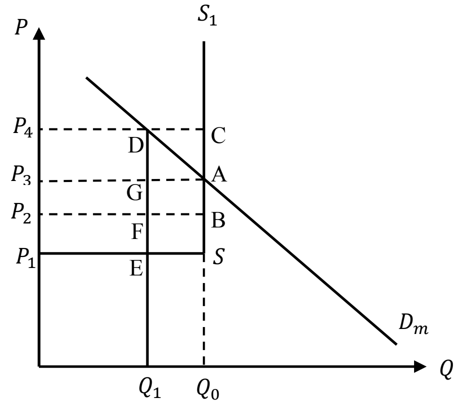
Multinational Enterprises The notion that multinational enterprises (MNEs) are playing a more and more important role in both domestic and international economic activities is widely accepted today. Therefore, one should not ignore the MNEs, when looking for factors that determine the degree of pass-through (see Menon, 1995). The instability in foreign exchange markets have induced MNEs to actively employ intra-firm pricing policies which prevent or at least decrease the degree of transmission of exchange rate changes to selling prices in individual markets. The intra-firm pricing policies create a number of ways in which MNEs can shield themselves against exchange rates uncertainty, or large and unfavourable exchange rate shocks. One of the most common methods is the use of internal or intra-corporate exchange rates that apply to intra-firm transactions. These exchange rates may vary significantly from the true exchange rate for prolonged periods, since they act merely as a clearing mechanism for intra-firm trade.

The other method is that payments on intra-firms purchase can be timed to coincide with favourable exchange rates. The leverage available to the MNEs to determine the timing of payment on contracts through flexible internal credit arrangements would enhance the ability of subsidiaries to price to the market independently of current exchange rates. For example, a subsidiary would be in a much better position to continue to sell at pre-depreciation prices, in order to preserve market share, if it had the cooperation of the overseas supplier to defer payment until such time in the future when the currency recovers. The widespread use of these methods by MNEs have severely weakened the link between exchange rates and import prices.

Non-tariff Barriers to Trade The important role of non-tariff barriers to international trade in affecting the pass-through relationship has been emphasized by Branson (1989). He explains that depreciations in the presence of import restrictions will generally cut into the import premium, thus absorbing much of its impact, before it is reflected in prices. Only when the depreciation is large enough to push prices to the point where quantity restrictions are no longer effective, we will observe some pass-through. Figure 2.1 indicates the process by which quantity restriction (QR) influences the pass-through outcome. It is assumed that there is a small country which is a price taker with respect to imports. D_m, is the demand curve for imports, and the supply curve for imports is composed of the horizontal segment P_1S (reflecting the small country assumption), and the vertical segment when it faces the QR at quantity Q_0. The initial equilibrium is at point A, at market price P_3 and quantity

Q_0. As a result of this policy, the seller will obtain P_1SAP_3 as rent. Assume that there is initially a small depreciation of the currency. While the vertical portion of the supply curve will not change, the horizontal portion will shift to P_2B. The market price will remain at P_3, however, the depreciation leads to reduction of the rents obtained by the seller (now reduced to P_2BAP_3). The pass-through of the depreciation is zero. Now consider the case where the depreciation is large enough to push the price up to the point where the quota is no longer effective. The depreciation shifts the horizontal portion of the supply curve up to P_4C, which is higher than the original market price of P_3. The equilibrium quantity now falls below the quota limit to Q_1. It is clear that pass-through is less than one in this case.

Figure 2.1: The Effect of Non-Tariff Barriers on Exchange Rate Pass-Through



Other Discussions on Exchange Rate Pass-Through Although the usual context for "perverse pass-through" is the inter-temporal concern, Hens et. al. (1999) show that the strategic reaction of oligopolists and the general cost function alone can cause perverse pass-through. In their model, they consider two duopolistic firms which both operate in two countries. The markets of the two countries are separate and each of the firms produces its good in one of these countries. In this setting, the direction and magnitudes of price movements as a result of changes in exchange rate will depend mainly on the extent of economies of scope and the strategic impacts of competitor's sales on their marginal profits. They provide results showing that if firms have constant marginal costs, or if there are economies of scope and strategic complements, then there is a simple monotonic relation between the prices in each country and the exchange rate. But with more general cost functions, both prices may change in the same direction and they may even increase in the market whose currency appreciates and decrease in the market whose currency depreciates. The latter would be true even if firms are identical and demand functions are linear.

There are a number of studies that address asymmetric price response to exchange rate changes. Marston (1990) found that the pass-through is larger when the importer's currency appreciates than when it depreciates. However, the opposite result is indicated by Goldberg (1995). Yang (2007) found little evidence of asymmetry in the response of prices to exchange rate changes. From the exporter's perspective, Han and Suh (1996) theoretically derive and empirically show that if the bargaining power of buyers is larger than that of exporters, both the short-run and long-run degree of pass-through during the appreciation period is larger than that during the depreciation period. It seems more studies are needed to explain the discrepancy among this literature.

2.2.2 Review of Empirical Studies on Exchange Rate Pass-Through

2.2.2.1 Studies Based on Imperfect Competition and Aggregate Data

A major part of the empirical literature on exchange rate pass-through is the group of studies that estimates the magnitude of pass-through to import or export prices and a few cases to domestic producer or consumer prices by recognizing the role of factors such as trade barriers, transportation costs, market power, the imperfect substitutability of comparable domestic and foreign products and so on. Among them, a number of studies use aggregate data in estimation while employing imperfect competition as the theoretical structure. Although these studies could not provide a systematic analysis of the micro determinants of pass-through because imperfect competition is an industry-specific characteristic and aggregate data does not necessarily behave as industry data, they are able to show the nature of pass-through at the country level. Some of the important studies in this era have been summarized in Table 2.2. Although there are some conflicting results in these studies and need for more investigation, the main finding is that exchange rate pass-through is incomplete even in the long run and international differences in pass-through are mainly determined by inflation rates and the trade composition of individual countries. Except for Kreinin (1977), Spitaller (1980), and Choudhri and Hakura (2006), other studies are based on the approach presented in Hooper and Mann (1989) which is a mark up model of price determination.

Hooper and Mann try to estimate the extent of the exchange rate pass-through to both the average price of total U.S. imports of manufactured goods and the price of imports of manufactures from Japan. Based on the mark up model of price determination, they assume that exporters have some degree of control over their price in the destination (U.S.) market.

The typical foreign firm sets the price of its exports to the U.S. in its own currency (PX_t^*) at a mark-up (λ_t) over its marginal cost of production (C_t^*):

$$PX_t^* = \lambda_t C_t^* \tag{2.4}$$

The U.S. import price, in dollars, is derived through multiplying the export price by the foreign currency exchange rate:

$$PM_t^{\$} = ER_t \lambda_t C_t^* \tag{2.5}$$

The mark-up, λ, is assumed to be variable and to respond to both competitive pressures in the U.S. market, measured by the gap between the competitors' prices in the U.S. market and foreign production costs in dollars, and demand pressures in all markets combined, measured by capacity utilization. Thus, the mark-up is specified as:

$$\lambda_t = (\frac{P^{\$}}{ER_t C_t^*})^{\alpha} (CU_t^*)^{\beta} \tag{2.6}$$

where $P^{\$}$ is the average U.S. price level of the good in question, and CU_t^* is the capacity utilization of the foreign firm. Substituting the mark up equation into the U.S. import price equation and taking logarithms of the result yields :

$$pm_t^{\$} = (1-\alpha)er_t + (1-\alpha)c_t^* + \alpha p^{\$} + \beta cu^* \tag{2.7}$$

where lowercase letters denote logarithmic values. The pass-through coefficient is $(1-\alpha)$, which we expect to be positive and less than one considering that $0 < \alpha < 1$. If α is equal to one, pass-through is zero. In this case, as can be seen in equation 2.6 , holding cu_t^* unchanged, the mark-up absorbs the shock to the exchange rate and therefore, exchange rate changes have no effect on the foreign prices. On the other hand, if the foreign firm does not face competition in the U.S. market and α is equal to zero, changes in the exchange rate are passed through completely, and the mark-up is left unchanged.

The specified model in equation 2.7 has some important limitations. The first is that it is a partial-equilibrium model and does not account for indirect effects of exchange rates on the import price through their effects on the other determinants of import prices such as foreign costs. To provide a more general model, foreign costs are considered as a function of the exchange rate and other factors (cx_t^*); $c^* = -\phi er_t + cx_t^*$ and therefore the model is modified as follows:

$$pm_t^{\$} = (1 - \alpha - \phi + \alpha\phi)er_t + (1 - \alpha)cx_t^* + \alpha p^{\$} + \beta cu^* \tag{2.8}$$

Given that $\phi > 0$ and $\alpha < 1$, the pass-through coefficient is smaller when c^* is specified as a function of the exchange rate and other factors relative to the case where it was exogenous in equation 2.7.

The second limitation is that the model is restrictive in the way that it imposes the same rate of pass-through on exchange rates and foreign costs (see equation 2.7). But as we know, exchange rates tend to be much more variable over time than production costs. Firms may be more willing to absorb into their profit margins changes in exchange rates (under the expectation that they are likely to be reversed in the near future) than to absorb changes in costs, which are more likely to be sustained. Accordingly, they estimate a version of the price equation that relaxes these restrictions on the exchange rate and cost coefficients.

The third limitation of the model is that it is static. The pass-through of a given exchange rate change may well change over time. In particular, firms may be willing to squeeze their profit margins initially in response to a decline in the dollar, but not indefinitely. If profit margins were returned gradually to desired levels, other things being equal, pass-through would tend to build up gradually over time. To allow for this possibility, they specify the import price equations as distributed lag on the competitiveness coefficient, α: α_0, α_1, ... α_T. In this case, the short-run pass-through coefficient (or the contemporaneous effect of the exchange rate on the import price) would be (1 - α_0); long-run pass-through would be (1 - $\sum_{i=1}^{T} \alpha_i$).

In summary, the provided framework by Hooper and Mann is able to capture several things: (1) the degree of pass-through at both the industry and country level, (2) the adjustment of mark-up to the exchange rate changes, (3) indirect effects of exchange rates on the import price, through their effects on the other determinants of import prices such as foreign costs, (4) how exchange rate pass-through to the import price changes over time.

The equations were estimated, for both total imports of manufactured goods and imports of manufactured goods from Japan, using quarterly data over the period 1973:1 through 1988:2. The results indicate that 50 to 60 percent of the change in the nominal exchange rate is reflected in prices of manufactured imports[1] which suggests that foreign firms on average sustain substantial shifts in the profit margins on their exports to the United States

[1]The pass-through coefficient for U.S. imports from Japan is about in line with the average for total U.S. imports.

as exchange rates change. However, given the tendency of even major changes in exchange rates to be reversed over time, a relatively low pass-through coefficient in the long run does not necessarily imply permanent shifts in profit margins. Moreover, they find little evidence that the pass-through relationship has changed over time.

The data and findings of the other studies that applied the same framework have been reported in Table 2.2.

Table 2.2: Selected Empirical Studies on the ERPT Using Mark-Up Approach

Author(s) of Study	Data	Method and Model	Findings
Krenin (1977)	Study the overall import and export prices (unit values) in a multi-country framework (U.S., Germany, Japan, Italy, Canada, and Belgium). It is concerned with estimating pass-through effects of the exchange rate changes agreed upon under the Smithsonian Agreement of 1971. Annual data from 1970 to 1972 are used.	The control country method is used to estimate pass-through. Specifically, the change in the i country's export (import) prices relative to the control country (a county with similar features) is divided by the change in the i country's exchange rate relative to the control country.	Pass-through generally incomplete and vary inversely with the size of the country. Pass-through to import price for individual countries as a result of a ten percent depreciation are: 50 percent, 60 percent, 80 percent, 90 percent, and 100 percent respectively for the U.S. Germany, Japan, Canada, Belgium and Italy. On the export side, the pass-through coefficients are 100 percent, 90 percent, 85 percent, 60 percent, 75 percent, 100 percent, respectively.
Spitaller (1980)	Study the magnitude and short-run time path of the effects of exchange rate changes on overall export and import unit values. The countries in the sample are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom, and the United States. Monthly data from January 1973 to April 1978 are used.	Using a simple model of export demand and export supply, he analyzes the effects of exchange rate changes on export unit values. In a distributed lag equation, the percentage changes in export unit values are regressed on corresponding changes in exchange rates, competitor prices, and production costs. Moreover, a behavioral relationship for changes in import unit values is provided and accordingly , percentage changes in import unit values are expressed as a distributed lag function of changes in exchange rates and suppliers' average export prices.	The estimated short-run exchange rate effects on export unit values are relatively low and slow while it seems that the pass-through of an exchange rate change to import unit values is complete in all countries other than Germany. Generally, the response of export or import unit values to competitor or supplier prices in industrial countries appears to be both stronger and more rapid than the response to exchange rate changes.

Table 2.2: Continued

Author(s) of Study	Data	Method and Model	Findings
Swift (1998)	Study the pass-through of exchange rate changes to the destination-currency prices of aggregate Australian exports. It is tried to test the validity of the "small country" assumption for aggregate Australian exports. Monthly data from the introduction of the flexible exchange rate regime for the AUD in December, 1983, until October, 1994 are used.	The paper uses the Johansen Multivariate Co-integration technique, which provides estimates for all the co-integrating vectors that may exist between the variables as well as short run dynamics, to estimate the pass-through of exchange rate. Domestic export prices, the world or competitor price index, exchange rate, and capacity utilization, as a proxy for demand pressure, are included in the estimated equation.	In this study, the pass-through of exchange rate changes to foreign currency prices for aggregate Australian exports was found to be around 60 percent and stable in the long run which refuses the "small country " assumption for aggregate Australian exports. Moreover, it is concluded that the ability of Australian exporters to set prices independently of macroeconomic conditions, with little long-term influence from competitors' prices, is the result of non-price strategies in imperfectly competitive markets, rather than simple price-taking competitiveness.
Doyle (2004)	Investigate the extent and speed of exchange rate and production cost pass-through into the unit values of total Irish imports from the UK. Quarterly data from 1979 to 1995 are used.	Based on the mark-up model in which import price is a function of exchange rate, producer costs and domestic competing prices, and employing co-integration and error-correction techniques, empirical model is estimated.	The results show that while pass-through is incomplete in the short-run, full pass-through from the bilateral exchange rate and from UK producer costs could not be rejected for total import unit values in the long-run. Moreover, the results imply no role for domestic competing prices in explaining the long-run relationship determining unit values of Irish imports from the UK.

Table 2.2: Continued

Author(s) of Study	Data	Method and Model	Findings
Campa and Goldberg (2005)	This study provides cross-country, and time series evidence on the pass-through of exchange rates into import prices across a large sample of OECD countries. Quarterly data, for 23 OECD countries, from 1975 to 2003 are used.	By assuming that the import prices for any country are a transformation of the export prices of that country's trading partners, using the exchange rate (domestic currency per unit of foreign currency) and the export prices, in turn, are a markup over exporter marginal costs, import prices are specified as a function of exchange rate, markup and marginal costs in exporter country. Then, by assuming that markup is a function of exchange rate and marginal costs are rising with export market wages and destination market demand conditions, the import prices are considered as a function of exchange rate and GDP in importing country and wages in exporting country. Then, this equation (with the addition of lagged exchange rate and foreign wages) is estimated in first difference for each of the 23 countries. In next stage, the estimated pass-through rates are explained based on macroeconomic variables.	The results show that, in average, import prices in local currencies reflect 46 percent of exchange rate fluctuations in the short run. In the longer run, pass-through elasticities are closer to 1 in many countries. Macroeconomic variables play a significant but limited role in explaining cross-country differences in levels of pass-through elasticities. Most notably, pass-through into import prices is lower for countries with low average inflation and low exchange rate variability.

Table 2.2: Continued

Author(s) of Study	Data	Method and Model	Findings
Choudhri and Hakura (2006)	Study domestic prices (CPI) to test the hypothesis that a low inflationary environment leads to a low exchange rate pass-through to domestic prices. The paper explores a model of the exchange rate pass-through, which emphasizes the role of price inertia and expectations. As prices are set for several periods in the model, the pass-through includes the expected effect of changes in the exchange rate on future costs and prices. The expected effect depends on the inflation regime. Therefore the model implies the hypothesis that the exchange rate pass-through is larger in high inflation regimes. A large database that includes annual data from 1979 to 2000 for 71 countries is used to estimate this relation.	Based on new open-economy macroeconomic models, the paper derives a pass-through relation in which the domestic price is specified as a function of its lags, the effective nominal exchange rate and the foreign prices (CPI). Then this model is estimated for three different inflation regimes (low, moderate and high inflation groups are defined as countries with average inflation rates less than 10 percent, between 10 and 30 percent and more than 30 percent, respectively). To further examine the effect of the inflation rate on the pass-through, another regression analysis is undertaken in which the estimated pass-through rate is regressed on inflation rate, inflation variability, exchange rate volatility and the degree of openness.	Results provide strong evidence that the relation between the pass-through and the average inflation rate is positive and significant across regimes. This relation remains robust even when it is controlled for other macroeconomic variables.

Table 2.2: Continued

Author(s) of Study	Data	Method and Model	Findings
Brissimisa and Kosma (2007)	Study total US import prices from Japan (measured by import unit values) to investigate the relationship between market power, as measured by market share, and incomplete exchange rate pass-through. It is argued that the main drawback of previous specifications for pass-through estimation is that they do not explicitly take into account market structure or market share by firms. Thus, it is tried to estimate an extended model that allows market power to play a role in the determination of the pass-through. Quarterly data from 1975 to 2001 are used.	Unlike previous studies on the exchange rate pass-through, the paper does not assume a priori the existence of market power but initially estimates a benchmark model of the law of one price type. Estimation results indicate that departures from perfectly competitive market structures are significant and that Japanese firms possess market power in the US market. They thus adopt a Cournot model and derive an equilibrium pricing equation as a first-order condition from profit maximization by Japanese firms. In this equation, US import price is a function of exchange rate, Japanese producer prices and the ratio of US imports from Japan to total US imports. An interesting feature of this model is that it explicitly accounts for the negative relationship between market power and the exchange rate and therefore it is concluded that pass-through is incomplete. Then, the derived equation is estimated on time series data with the Johansen multivariate co-integration technique.	The results from estimating the equilibrium pricing equation indicate that market power, measured by market share, does not appear to influence significantly the pricing decisions of Japanese firms. Therefore it is concluded that future research could focus on uncovering other determinants of incomplete pass-through such as other sources of market power not captured by market share or factors underlying changes in Japanese firms' cost structure.

Table 2.2: Continued

Author(s) of Study	Data	Method and Model	Findings
Ghosh, and Ramkishen (2007a)	Study domestic prices (CPI) to analyze whether exchange rate pass-through in India has changed over time, particularly since 1991, which was the beginning of the country's economic liberalization program. Quarterly data from 1980 to 2005 are used.	A model in which the domestic prices (measured by CPI) is a function of exchange rate (measured by bilateral-U.S. dollar), the cost conditions in the exporting market (measured by the U.S. PPI) and demand conditions in the importing market (measured by using the overall industrial production index of India) is specified and estimated by ECM method for full sample and two sub-periods, namely 1980Q1-1990Q4 and 1992Ql-2005Q3.	The results show that the exchange rate pass-through elasticity of the bilateral exchange rate of the Indian rupee with the USD to be about 40 per cent for the entire period in the long run, while it is considerably smaller in the short run (10 per cent). Moreover, results suggest some evidence of a slightly higher pass-through for the post-liberalization era, which is consistent with greater openness of the country to external influences.
Ghosh, and Ramkishen (2007b)	Study the degree of ERPT into the export prices of three Asian economies Korea, Thailand and Singapore using US dollar bilateral rates. The study also examines whether there are asymmetries in ERPT between exchange rate appreciation and depreciation. Quarterly data from 1980 to 2006 are used.	A model in which the export price index of any of the three nations is a function of exchange rate (measured by bilateral-U.S. dollar), cost conditions in each economy by using their respective producer price index (PPI), and destination market demand conditions in the USA by using the U.S. gross domestic product (GDP) is specified and estimated by ECM method.	The long-run exchange rate pass-through to export prices are around 86, 85, and 60 percent in Korea, Singapore, and Thailand respectively while the short run elasticities are 75, 70, and 40 percent. In the case of Korea, and Singapore, it appears that there is greater ERPT with a depreciation of the domestic currency with respect to the USD than an appreciation, but the opposite is observed in the case of Thailand.

Table 2.2: Continued

Author(s) of Study	Data	Method and Model	Findings
Marazzi and Sheets (2007)	Study the U.S. aggregate import prices to investigate the decline in exchange rate pass-through from 1970s to last decade. Quarterly data from 1972 to 2004 are used.	Based on the traditional mark-up pricing model, an equation in which the U.S. aggregate import prices is a function of foreign production costs expressed in dollars and primary commodity prices in dollar, to control for indirect effects of exchange rate on import prices, is specified and estimated in logarithm form of first difference. The model is estimated for full sample as well as sub-samples of 1972Q4-1984Q4, 1985Q1-1994Q4, and 1995Q1-2004Q4.	The results show a robust and sustained decline in exchange rate pass-through from well above 0.5 during the 1970s and 1980s to around 0.2 over the last decade. This decline is attributed to the rising prominence of competition from China, a shift in import pricing behavior since the Asian financial crisis, pricing to market behaviour, and the reduced share of material-intensive goods in U.S. imports. These results point to a new and more general hypothesis linking the decline in pass-through to the evolving nature of competition in global markets and structural changes in international patterns of production. At root, these developments reflect the evolution of technology, reduced transportation costs, declining barriers to trade, and improved macroeconomic policies.

Despite its popularity in empirical research, the mark-up model of price determination, specially in the context of aggregate data, does not explain the determinants of markup adjustment, which may include trade barriers, transaction and transportation costs, market power, the imperfect substitutability of comparable domestic and foreign products and so on.

2.2.2.2 Studies Based on Imperfect Competition and Disaggregate Data

The employment of disaggregate data in micro models of price determination provides the opportunity for estimation of the variation of pass-through across industries and the analysis of the micro determinants of pass-through. In what follows, we try to summarize the main models employed in the empirical estimations.

The first study in the context of micro models and disaggregated data was presented by Feinberg (1986). Using a price-leadership model in which domestic firms dominate a homogenous product market, Feinberg shows that the extent of exchange rate pass-through to domestic producer price depends on market concentration and the share of import in domestic sale. To examine the empirical link between movements in the real value of the Deutsche Mark and relative producer prices, he analyzes annual data from 1977 to 1983 for each of 41 German industries (defined between the 3- and 4-digit SIC level used by the US Census Bureau). As mentioned, this link is affected by seller concentration (measured by a Herfindahl index, H) as well as by import shares (M), which will proxy to some extent the absence of trade barriers. Therefore, the following regression equation is estimated on 287 pooled cross-section/time-series observations (i = 1, ... ,41; t = 1977,..., 1983), using the least-squares-with-dummy-variables for each sector:

$$\ln RPPI_{ti} = a_0 + a_1 \ln GNP_t + a_2 \ln REXCH_t + a_3 \ln M_{ti} \ln REXCH_t + a_4 \ln H_{ti} \ln REXCH_t \tag{2.9}$$

Where $RPPI$ is the relative domestic producer price index, GNP is the index of real GNP and $REXCH$ is the index of the trade-weighted external real value of the Deutsche Mark.

The results show that the exchange rate pass-through is -0.2; that is, an appreciation of 10 percent in the real external value of the Deutsche Mark is predicted to lower producer prices of traded goods relative to overall inflation by two percent on average. 10 percent increase in M increases the response elasticity by 0.001, although this import effect is not statistically significant. 10 percent increase in concentration reduces the (absolute value of the) elasticity by only about 0.001. Although this model improves the literature by considering the role of the market power of domestic firms in price determination, it assumes perfect substitution between domestic and foreign products, which is somewhat unrealistic, and consequently accepts that the exchange rate pass-through to domestic and import prices are identical.

As mentioned in the theoretical section, using an imperfect substitutes trade model with an oligopolistic domestic market structure, Feinberg (1989) shows that there is a positive relationship between exchange rate pass-through and the domestic currency share of imported inputs in cost, the pass-through into import prices, the degree of substitutability between imports and domestic products, and each firm's conjecture (as to the increase in market output due to a one unit increase in its own output) while the number of domestic firms in the market decreases the exchange rate pass-through. To examine empirically these relationships, a two-stage procedure is considered: (1) a simple model with industry intercept and slope dummy variables is used to estimate an elasticity of response specific to each industry between the real exchange rate and relative producer prices, using the pooled cross-section/time series data (14 years of data (1974 to 1987) for each of 84 U.S. manufacturing industries, defined at the 4-digit SIC level):

$$\ln RPPI_{ti} = a_0 + a_1 \ln GNP_t + a_2 \ln REXCH_t \tag{2.10}$$

where $RPPI$ is the relative domestic producer price index, GNP is the index of real GNP and $REXCH$ is the index of real multilateral trade-weighted value of the dollar; (2) a cross-section model is used to explain differences across industries in the estimated response elasticity by a series of industry variables derived in the theoretical model. The results show that the factors with statistically significant effects are as follows: doubling the substitutability of imports for domestic product, ceteris paribus, implies an increase of 0.04 in the absolute value of exchange rate pass through elasticity; doubling the importance of selling expenses (as measures of potential barriers to new entry) in an industry reduces the absolute value by 0.06. On the other hand, a doubling in the share of costs attributed to imported inputs increases the elasticity by 0.16, while a doubling in capital intensity (as measures of potential barriers to new entry) reduces the elasticity by that same amount. The limitations of this model are related to assumption of constant marginal cost, and minimal role for strategic importer pricing behavior.

Based on this theoretical framework and two stage procedure, Feinberg (2000) examines three developing countries-Colombia, Korea, and Morocco and found incomplete pass-through into domestic prices, but greater impact than previously found for developed economies. An important common result is that entry and entry barriers seem to matter in the transmission of exchange rate changes into domestic prices, suggesting that increased openness to imports has only limited influence on domestic prices of import competing goods, and can be aided by domestic competition policy.

Assuming imperfect substitution between domestic and foreign products, strategic interaction between domestic and foreign producers, and increasing marginal cost, Yang (1997) provides a detailed model on exchange rate pass-through to import prices which implies that, in general, exchange rate pass-through to import prices is incomplete and is negatively affected by the degree of substitution among different variants in the industry, the elasticity of marginal cost with respect to output, and market share of foreign firms. The empirical test follows a two-stage estimation procedure. In the first stage, after recognizing that series contain unit roots, the first differences of the time series variables are used for estimation of exchange rate pass-through in each industry as follows:

$$\triangle \ln MP_{k,t} = a_{1,k} \triangle \ln EXR_t + a_{2,k} \triangle \ln PP_{k,t} + a_{3,k} \triangle \ln MP_{k,t-1} + v_{k,t} \tag{2.11}$$

where $MP_{k,t}$ is the import price index for industry k, EXR_t is the reciprocal of the nominal effective exchange rate index for the U.S. dollar, and $PP_{k,t}$ is the corresponding domestic price index for industry k. $a_{1,k}$ is the short run elasticity of exchange rate pass-through. In contrast to Feinberg (1989), a lagged dependent variable is also included in this model. This is likely due to the fact that this study employs quarterly data while Feinberg employs annual data. This equation is estimated for 51 three-digit and 36 four-digit SIC industries using quarterly data from 1980 to 1991. The second-stage regression model is specified as:

$$a_{1,k} = c_0 + c_1 PD_k + c_2 EMC_k + c_3 MR_k + v_k \tag{2.12}$$

where PD_k is a variable measuring the degree of product differentiation for industry k (proxied by four different variables: the ratio of scientists and engineers to total employment, the ratio of nonproduction workers to total employment, advertising intensity, and the intra-industry trade index=$1 - \frac{|X_k - M_k|}{X_k + M_k}$), EMC_k is a measure of the elasticity of marginal cost (proxied by capital to labour ratio), MR_k is the ratio of total imports to total supply in the industry. The results of first stage show that the average pass-through elasticity for the sample is 0.318 varying from 0.02 (for hardwood veneer and plywood) to 0.757 (for printing trades machinery). For ten industries the elasticity is negative but insignificant. In second stage, except the share of total imports in total supply which is not significant, other variables have the expected sign and are statistically significant. The limitation of this analysis is that it does not specify the cost structure, therefore neglects the effect of imported inputs on exchange rate pass-through.

There is some literature that is close to the approaches presented by Feinberg and Yang. Kardasz and Stollery (2001) examine the pass-through of exchange rate changes to the real prices of domestically produced and imported goods in Canadian manufacturing industries through industry estimates of pass-through elasticities and a cross section analysis of their determinants. By considering the imperfect substitutability between domestic and foreign products in a Cournot competition model and assuming constant marginal cost, they implicitly derive the reduced form price equations from the first order conditions of profit maximization as follows:

$$p_i = p_i(c_d, c_m, n_d, n_m, y) \qquad i = d, m \tag{2.13}$$

where p_i is the real price of domestic or foreign product (in domestic currency), c_d and c_m are the real marginal cost of domestic and foreign product (in domestic currency) respectively, n_d and n_m are the numbers of domestic firms and foreign firms respectively, and y is real income (in domestic currency). In this equation, $c_m = C_m/P = e(C_m^*/P^*)(1+t)$ and therefore the real exchange rate (e) can affect p_i directly via c_m and also indirectly through c_d because e can affect the price of imported materials used by domestic producers (p_{mat}). Therefore, the total exchange rate pass-through elasticity can be written as:

$$\alpha_{ie} = \alpha_{im}\frac{d\ln c_m}{d\ln e} + \alpha_{id}\frac{d\ln c_d}{d\ln p_{mat}}\frac{d\ln p_{mat}}{d\ln e} \qquad i = d, m \tag{2.14}$$

Where $\alpha_{ie} = \frac{d\ln p_i}{d\ln e}$ is the exchange rate pass-through elasticity for p_i, $\alpha_{im} = \frac{d\ln p_i}{d\ln c_m}$ and $\alpha_{id} = \frac{d\ln p_i}{d\ln c_d}$ are the cost pass-through elasticities. The standard theory of cost minimization implies that $\frac{d\ln c_d}{d\ln p_{mat}}$ equals the material share (μ). Assuming that c_m is proportional to e, replacing $\frac{d\ln p_{mat}}{d\ln e}$ by β, and representing the exogenous determinants of own price elasticities by vector Z_i, the analysis can be summarized by the following equation:

$$\alpha_{ie} = \alpha_{ie}(n_d, n_m, Z_i, \mu\beta) \qquad i = d, m \tag{2.15}$$

Similar to Feinberg (1989, 2000) and Yang (1997) a two stage estimation procedure is employed. In the first stage, equation 2.16 is estimated for domestic and import prices for thirty-one Canadian manufacturing industries at the L-level of aggregation from 1972 to 1989:

$$\triangle \ln p_i = a_0 + a_1 \triangle \ln e + a_2 \triangle \ln p_{us} + a_3 y_{err} + a_4 T \qquad i = d, m \tag{2.16}$$

where p_{us} is the real price in the matching U.S. industries, T shows time to capture the effects of variables like productivity that may vary systematically with time, y_{err} is the trend free residual obtained by regressing the first difference of the logarithm of real GDP against time and time square to control for business cycles in Canada. The results show that, on average, a 10 percent depreciation of the Canadian dollar will increase the price of imports by 2.55 percent and the price of domestically produced goods by 1.24 percent. In the second stage, equation 2.15, in which n_d proxies by the Herfindahl index of concentration and Z_i includes advertising sale ratio, rate of price protection and the share of imports, is estimated. The results indicate that industry values of the pass-through elasticities for domestic goods increase with the advertising intensity of domestic producers (as a measure for product differentiation). On the other hand, the exchange rate pass-through to imports tends to be high in industries with high price protection and low advertising intensity.

Using a similar theoretical framework, Kardasz and Stollery (2005) try to estimate the direct and indirect exchange rate pass though elasticities to imports and domestic prices. As equation 2.14 shows, the direct effect is related to the impact of the exchange rate on the marginal cost of imports; while the indirect effect is related to the impact of the exchange rate on the price of materials used by domestic producers and hence on their marginal costs. To estimate the direct and indirect effects, the first stage equations are specified as follows:

$$\triangle \ln \tilde{p}_d = \alpha_0 + \alpha_1 \triangle \ln p_m + \alpha_2 \triangle \ln p_{mat} + \alpha_3 \triangle \ln w + \alpha_4 \triangle \ln tfp + \alpha_5 y_{err} \qquad i = d, m \tag{2.17}$$

$$\triangle \ln p_m = \beta_0 + \beta_1 \triangle \ln \tilde{p}_d + \beta_2 \triangle \ln e + \beta_3 \triangle \ln c_{US} + \beta_4 y_{err} \qquad i = d, m \tag{2.18}$$

$$\triangle \ln p_{mat} = \gamma_0 + \gamma_1 \triangle \ln e + \gamma_2 \triangle \ln p_{matu} + \gamma_3 y_{err} \qquad i = d, m \tag{2.19}$$

where (w) is the real wage rate, p_{matu} is the price of materials in matching US industries, and (tfp) is an index of total factor productivity. These equations are estimated (the first two ones using 2SLS with the lagged exogenous variables as instruments and the last one using OLS) using data from 1961 to 1995 for 37 L-level industries in the Canadian manufacturing sector. Then, based on equation 2.14, the direct and indirect effects are calculated. The average values of the direct and indirect elasticities are 0.162 and 0.140 for domestic goods and 0.564 and 0.067 for imports. These values imply that, on average, a real depreciation makes imports less competitive because the gap between the direct elasticities (0.402) exceeds the gap between the indirect elasticities (0.073). For a small number of industries, the net result of the direct and indirect effects is that a depreciation of the domestic currency increases the competitiveness of imports, contrary to conventional analysis. In the second stage, the determinants of exchange rate pass-through are examined in a cross-section analysis. Important determinants of the direct (indirect) elasticities are the import share and non-tariff barriers (the responsiveness of domestic costs to changes in the exchange rate, and concentration).

Acknowledging the important role of foreign competitors in disciplining the domestic market, Banik and Biswas (2007) analyze exchange rate pass-through in the presence of monopolistic competition in the U.S. automobile market. The empirical model used for the analysis is the Johansen co-integration technique. By assuming that exchange rates follow a random walk, they express the pricing equation as a function of present and past values of the variables:

$$p_t^k = f(p_t^j, p_{t-i}^j, E_t^k, E_{t-i}^k) \tag{2.20}$$

where p is the per-unit import price in US dollar, E is nominal exchange rates defined as source-country currency per \$U.S., k and j are exporting countries, $j \neq k$, t is the time period, and $i = 1, ..., n$. It is assumed that exchange rates are exogenous variables, affecting import prices but not influenced by the prices in return. In this study, pricing of small and medium size automobiles are analyzed using monthly data from July 1991 to December 1999. For small size automobiles, the pricing behavior is analyzed for only between Japan and Canada as producers while for medium size automobiles, they analyze the pricing behavior among producers from Japan , Korea, and Canada.

To determine the price interaction among the foreign producers, a two-step procedure is followed. In the first step of the analysis, the co-integration between prices, based on an unrestricted vector autoregressive (VAR) model, is examined. In the second step, they take into account the restrictions imposed by the theoretical framework. For this purpose, they use a vector error correction (VEC) framework, where it is possible to impose restrictions such that local currency prices of the foreign exporters are affected only by movement of their own exchange rates and rival's prices. In first stage, one co-integrating vector is found for each of the small and medium size automobiles. The co-integrating relationship for small automobiles identifies a stable time-trend relationship among the prices and indicates that Japanese per unit export prices are associated with a positive movement in Canadian per unit export prices. The co-integrating relationship for medium automobiles indicates that Japanese per-unit export prices are associated with a negative movement in Canadian per unit export prices and with positive movement in Korean per-unit export prices

In the second step, the VEC model, in which the per-unit import price sequence from each country is represented as a function of its own lag, rivals' per-unit lagged export prices, lagged own exchange rates and the residuals from co-integrating equation, is estimated for both small and medium size automobiles.

$$\triangle p_t^k = \sum_{i=1}^{n} (\alpha_{ki} \triangle p_{t-i}^k + \beta_{ki} \triangle p_{t-i}^j + \gamma_{ki} \triangle E_{t-i}^k) + \Psi(\hat{\varepsilon}_{k,t-1}) + \varepsilon_{kt} \tag{2.21}$$

where $(\hat{\varepsilon}_{k,t-1})$ is the 1-month lagged disequilibrium residuals from the co-integrating equation. The results indicate that there are price interdependencies among small size automobiles. In this category, all the coefficients of prices are positive, indicating that each exporting country has an incentive to follow its competitor's price changes. For a 100 percent increase in Japanese prices, the Canadian prices increase by 15.34 percent. Likewise, Japanese prices react to Canadian price changes by around 26 percent. These findings suggest the existence of competition among the exporters selling automobiles in the small size category. For the medium size automobiles, although they find price interdependence between exporters from Japan and Korea, exporters from Canada do not react to Japanese export prices and respond negatively to Korean export prices. Japanese and Korean exporters do not respond to price changes by Canadian exporters.

Regarding exchange rate pass-through, with a 100 percent appreciation of Japanese yen against U.S. dollars, Japanese exporters increase their local currency price by around 13 percent for the small size automobiles, and around 39 percent for medium size automobiles. The results validate the economic intuition that a low degree of price competition corresponds with a high degree of exchange rate pass-through.

In general, the studies based on imperfect competition and disaggregate data show partial pass-through in industry level and even in commodity level. Moreover, these models have this ability to analyze the micro determinants of pass-through.

After a detailed review of the theoretical and empirical studies on the exchange rate pass-through, here we should specify the features of our theoretical framework. Clearly, it is impossible to include all the above theoretical and empirical concerns into a single paper. Therefore, it is necessary to indicate which are and which are not incorporated in this study. The provided literature, except the structural models of pass-through such as hysteresis models which are empirically difficult to investigate, introduces four major factors that explain why exchange rate pass-through could be different from one and different across sectors: imperfect substitution between domestic and foreign products, strategic interaction between domestic and foreign producers, (share of) tradable inputs in production costs, and increasing marginal cost. Although each of these factors (or some of them) have been examined separately in different studies, there is not a general model that incorporate all of these factors together. For example, Dornbusch (1987) emphasizes the role of the product differentiation, Feinberg (1989) demonstrates the implications of imported inputs, Sibert (1992) examines the effects of market shares of foreign firms, Feenstra (1989) explains the role of the underlying cost functions on exchange rate pass-through. While Yang(1997) provides a relatively more comprehensive model, he ignores the role of (the share of) the tradable inputs. Our study tries to extend Yang's model by incorporating the role of the tradable inputs to provide a more general model to examine exchange rate pass-though.

2.3 Theoretical Framework for Exchange Rate Pass-Through: A Model with Product Differentiation

As it was demonstrated in the literature review, ignoring the dynamic aspects and hysteresis models of pass-through, there are four major factors that explain why exchange rate pass-through could be different from one: imperfect substitution between domestic and foreign products, strategic interaction between domestic and foreign producers, (share of) tradable inputs in production costs, and increasing marginal cost. While different studies have analyzed the role of one or some of these factors, there is not a general model that incorporate all of these factors together. For example, Feinberg (1989) and Feenstra (1989) have ignored the strategic interaction between foreign and domestic producers. On the other hand, although Fisher (1989) and Sibert (1992) model strategic interaction between foreign and domestic producers, it is done at the expense of treating imports and domestic goods as perfect substitutes. Feinberg (1989), Fisher (1989), and Sibert (1992) have assumed that the marginal cost is constant. Yang(1997) ignores the role of (the share of) the tradable inputs while it has been emphasized by Feinberg (1989).

This study tries to contribute to the literature by providing a more comprehensive model of pass-through which incorporates all four major related factors. To do this, we develop the Dixit-Stiglitz model in Dornbusch (1987) and Yang (1997) by incorporating the effect of tradable inputs on exchange rate pass-through. Therefore, our theoretical framework differs from them in two aspects. First, this study provides a specific solution for exchange rate pass-through to domestic produce price rather than the foreign firm's price. Second and more importantly, input prices (wages, intermediate material prices) are included in the marginal cost function and their role in price determination and consequently the role of imported (tradable) inputs in exchange rate pass-through determination are examined.

We consider the domestic market for differentiated products, which belong to a well-defined industry category but imperfect substitutes for each other in the eyes of consumers, such as automobiles. We assume that some of the varieties are produced domestically, while others are imported. We also assume that the individual firm is sufficiently large to affect industry price and firms respond to changes in industry price.

2.3.1 Demand Side

The representative consumer in this model maximizes a utility function V with a number of subutility functions that have the property of "Homogeneous functional separability " so that a two-stage maximization procedure is consistent.

$$V = U(u(X), u(Y), u(Z), ...)$$

Each sub-utility function ($u(X)$) shows the utility of the differentiated products belonging to the same industry.

There are n_h domestic firms and n_f foreign firms, each supplying a different variety of the product in the market. To make the analysis easier, some simplifying assumptions are considered. First, all foreign firms are from one single country. Second, firms of the same country are identical. Third, there is an effective spatial separation between the home and foreign markets. The focus is on the pricing in the home market. With these assumptions, the analysis is equivalent to a two-firm model. Thus, as the Dixit-Stiglitz model, the subutility function X can be written as:

$$u(X) = X = [n_h X_h^{(\varepsilon-1)/\varepsilon} + n_f X_f^{(\varepsilon-1)/\varepsilon}]^{\varepsilon/(\varepsilon-1)} \tag{2.22}$$

where X_h and X_f indicate the consumed quantities of variants produced by the representative home and foreign firms respectively. $\varepsilon > 1$ is a measure of substitutability among the variants in a way that a larger ε presents a higher degree of substitution. The consumer's budget constraint for consuming X can be written as:

$$n_h P_h X_h + n_f P_f X_f = E_X \tag{2.23}$$

where E_X is the allocated income for the consumption of X and is determined through first stage maximization of the total utility function. The demand functions for the domestic and foreign variants in the domestic market are obtained by maximizing $u(X) = X$ subject to the budget constraint as follows:

$$Max\ u(X) = X = [n_h X_h^{(\varepsilon-1)/\varepsilon} + n_f X_f^{(\varepsilon-1)/\varepsilon}]^{\varepsilon/(\varepsilon-1)}$$
$$S.t.\ n_h P_h X_h + n_f P_f X_f = E_X$$

$$L = [n_h X_h^{(\varepsilon-1)/\varepsilon} + n_f X_f^{(\varepsilon-1)/\varepsilon}]^{\varepsilon/(\varepsilon-1)} - \lambda[n_h P_h X_h + n_f P_f X_f - E_X]$$

Using the first order conditions of the above Lagrange's equation, we have:

$$X_i = \frac{E_X}{P}(\frac{P_i}{P})^{-\varepsilon} \qquad i = h, f \tag{2.24}$$

where

$$P = [n_h P_h^{(1-\varepsilon)} + n_f P_f^{(1-\varepsilon)}]^{1/(1-\varepsilon)} \tag{2.25}$$

is the industry price. Therefore, the demand elasticity perceived by domestic or foreign firms in the domestic market can be derived as follows:

$$\xi_i = \frac{dlogX_i}{dlogP_i} = -\varepsilon + (\varepsilon - 1)\frac{dlogP}{dlogP_i} \qquad (logX_i = logE_X - \varepsilon \cdot logP_i + (\varepsilon - 1) \cdot logP)$$

$$\xi_i = -\varepsilon + (\varepsilon - 1)\eta_i \qquad i = h, f \tag{2.26}$$

where

$$\eta_i = \frac{dlogP}{dlogP_i} \tag{2.27}$$

is the elasticity of the industry price with respect to domestic or foreign firm's prices. Non-zero values for η_i means that each individual firm is large enough to affect industry price. It is shown that the η_i is firm *i's* market share:

$$\eta_i = \frac{dlogP}{dlogP_i} \qquad (logP = \frac{1}{(1-\varepsilon)} log[n_h P_h^{(1-\varepsilon)} + n_f P_f^{(1-\varepsilon)}])$$

$$\eta_h = \frac{dlogP}{dlogP_h} = \frac{dlogP}{dP_h} P_h = \frac{P_h}{1-\varepsilon} \cdot \frac{(1-\varepsilon) n_h P_h^{-\varepsilon}}{n_h P_h^{1-\varepsilon} + n_f P_f^{1-\varepsilon}} = \frac{n_h P_h^{1-\varepsilon}}{n_h P_h^{1-\varepsilon} + n_f P_f^{1-\varepsilon}} \tag{2.28}$$

By substituting 2.25 into 2.28 we have:

$$\eta_h = n_h \frac{P_h^{1-\varepsilon}}{P^{1-\varepsilon}} = n_h P^{\varepsilon-1} P_h^{1-\varepsilon} = n_h \frac{X_h}{E_X} P_h^{\varepsilon} P_h^{1-\varepsilon} = \frac{n_h X_h P_h}{E_X} = S_h \tag{2.29}$$

Similarly for the foreign firm we have:

$$\eta_f = S_f \tag{2.30}$$

Therefore, the demand elasticity perceived by any individual firm i can be rewritten as:

$$\xi_i = -\varepsilon + (\varepsilon - 1) S_i \qquad i = h, f \tag{2.31}$$

Equation 2.31 indicates that the demand elasticity facing any individual firm i is a function of the respective market share (S_i) and the degree of substitutability among variants (ε).

2.3.2 Supply Side

The individual imperfectly competitive firm i faces a demand curve as in 2.24. To be able to show the role of tradable inputs in exchange rate pass-through determination as our contribution to the literature, we specify the determinants of the cost function in the supply side of the economy. Letting $C(X_h, W_h, P_{mat.h}(P_{mat.f}, e))$ and $C(X_f, W_f, P_{mat.f})$ denote the costs of the domestic and foreign firms in their currencies respectively, and e the nominal exchange rate defined as the number of units of domestic currency per unit of foreign currency, the profit maximization problem for the representative domestic and foreign firms are:

$$\pi_h = P_h X_h - C(X_h, W_h, P_{mat.h}(P_{mat.f}, e)) \tag{2.32}$$

$$\pi_f = P_f X_f - e.C(X_f, W_f, P_{mat.f}) \tag{2.33}$$

where the costs (and also the marginal costs) are the increasing functions of the respective production level (X_h or X_f), wages (W_h or W_f) and the price of intermediate materials ($P_{mat.h}$ or $P_{mat.f}$). It is assumed that intermediate materials in domestic market $P_{mat.h}$ are imported from foreign country, therefore it is considered as a function of e and $P_{mat.f}$. As equation 2.33 shows, any change in the exchange rate represents a cost shock to foreign firm and to a lesser extent to domestic firm. The first order conditions for profit maximization can be derived as follows:

$$\frac{\partial \pi_h}{\partial P_h} = X_h + P_h \frac{\partial X_h}{\partial P_h} - C'_{X_h}(X_h, W_h, P_{mat.h}(P_{mat.f}, e)) \frac{\partial X_h}{\partial P_h} = 0$$

where C'_{X_h} is the marginal cost. Dividing both sides of the above equation by X_h yields:

$$1 + \xi_h - C'_{X_h}(X_h, W_h, P_{mat.h}(P_{mat.f}, e)) \cdot \frac{\xi_h}{P_h} = 0$$

By modifying the above equation, we can obtain the familiar markup pricing equation:

$$P_h = \frac{\xi_h}{1 + \xi_h} \cdot C'_{X_h}(X_h, W_h, P_{mat.h}(P_{mat.f}, e)) \tag{2.34}$$

The expression $\frac{\xi_h}{1+\xi_h}$ is referred as markup and as equations 2.26 and 2.28 show, it is a function of relative prices and the degree of substitutability among variants. Similarly for the foreign firm in the domestic market we have:

$$P_f = \frac{\xi_f}{1 + \xi_f} \cdot e \cdot C'_{X_f}(X_f, W_f, P_{mat.f}) \tag{2.35}$$

2.3.3 Market Equilibrium

By substituting the demand side of the economy (equations 2.24 and 2.25 as well as 2.26 and 2.28) in the supply side (2.34 and 2.35), we can derive the market equilibrium conditions as below:

$$P_h = \frac{1}{\frac{1}{-\varepsilon+(\varepsilon-1)\frac{n_h}{n_h+n_f(\frac{P_h}{P_f})^{\varepsilon-1}}}+1} \cdot C'_{X_h}(X_h = \frac{E_X}{P_h} \cdot \frac{1}{n_h + n_f(\frac{P_h}{P_f})^{\varepsilon-1}}, W_h, P_{mat.h}(P_{mat.f}, e)) \quad (2.36)$$

$$P_f = \frac{1}{\frac{1}{-\varepsilon+(\varepsilon-1)\frac{n_f}{n_f+n_h(\frac{P_f}{P_h})^{\varepsilon-1}}}+1} \cdot e \cdot C'_{X_f}(X_f = \frac{E_X}{P_f} \cdot \frac{1}{n_f + n_h(\frac{P_f}{P_h})^{\varepsilon-1}}, W_f, P_{mat.f}) \quad (2.37)$$

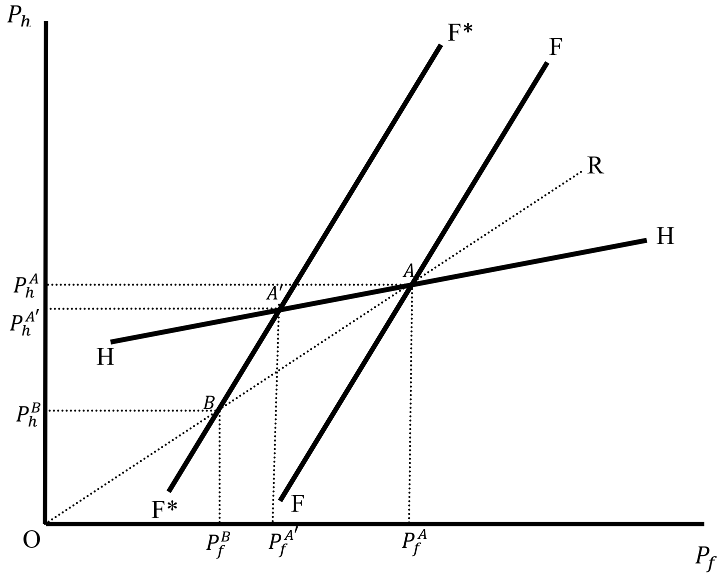
Equations 2.36 and 2.37 represent each firm's pricing policy in terms of a price reaction function. From these equations, it is clear that pricing decisions are interdependent and affected by same factors including degree of substitutability among the variants, the number of domestic and foreign firms, domestic income, domestic and foreign wages, foreign prices of intermediate materials and exchange rate. Specifically, we have:

$$P_h = H(\varepsilon, n_h, n_f, E_X, W_h, W_f, P_{mat.f}, e) \quad (2.38)$$

$$P_f = F(\varepsilon, n_h, n_f, E_X, W_h, W_f, P_{mat.f}, e) \quad (2.39)$$

Equation 2.36, the reaction of the domestic producer price to changes in the foreign firm's price, presents a positive but less than the proportional relationship between P_h and P_f. To see this relationship, assume that P_f increases. Then, the RHS of equation 2.36 increases and thus the LHS (P_h) should increase to create the equilibrium. However, the increase in P_h should be proportionally less than the increase in P_f because in the case of proportional change or more, the LHS of the equation increases while its RHS decreases and we will not have the equilibrium. Similarly the equation 2.37, the reaction of the foreign firm's price to changes in the domestic producer price, shows a positive but less than the proportional relationship between P_f and P_h. Therefore, as Figure 2.2 shows, in the space of P_h and P_f, the slopes of the domestic and foreign firms' reaction functions (HH and FF) are less and greater than one respectively. The point A shows the initial equilibrium.

Figure 2.2: The Effects of an Appreciation of the Domestic Currency



2.3.4 The Effects of Different Factors on Price Equilibrium

2.3.4.1 The Effect of Exchange Rate: Exchange Rate Pass-Through

Figure 2.2 can also show the effects of a domestic currency appreciation. To be able to show the role of imported (tradable) inputs in price equilibrium and exchange rate pass-through, assume that the intermediate inputs are not tradable and therefore their prices are not directly affected by the exchange rate. In this case, an appreciation will shift the foreign reaction function to the F^*F^* (see equation 2.37) while leaving the home country's reaction function in place. The magnitude of the shift in FF at given relative prices (for example, along the OR ray) is proportionally less than the appreciation. As equation 2.37 indicates, the decrease in P_f as a result of appreciation will lead to increase in the production level which, in turn, increases the production costs depending on the elasticity of the marginal cost with respect to output. Thus, at given relative prices, the percentage decrease in p_f $(\frac{AB}{AO} = \frac{P_f^A P_f^B}{OP_f^A})$ should be less than the percentage of appreciation to reach the equilibrium.

$$\frac{P_f^A P_f^B}{OP_f^A} < \frac{de}{e} \tag{2.40}$$

The new equilibrium is at A' and the change in the foreign firm's price is equal to $\frac{P_f^A P_f^{A'}}{OP_f^A}$ which is less than the percentage of appreciation as equation 2.40 indicates. Therefore, the exchange rate pass-through to the foreign firm's price (τ_f) is less than one. In other words, foreign firms reduce their price proportionally less than the domestic currency appreciation.

$$\tau_f = \frac{\frac{dP_f}{P_f}}{\frac{de}{e}} = \frac{\frac{P_f^A P_f^{A'}}{OP_f^A}}{\frac{de}{e}} < 1 \tag{2.41}$$

As it was explained in equation 2.36, the reaction of the domestic producer price to changes in the foreign firm's price is less than one. Thus, in the case of the appreciation, home firms cut their price but proportionally less than the reduction in the foreign firm's price.

$$\frac{\frac{dP_h}{P_h}}{\frac{dP_f}{P_f}} < 1 \tag{2.42}$$

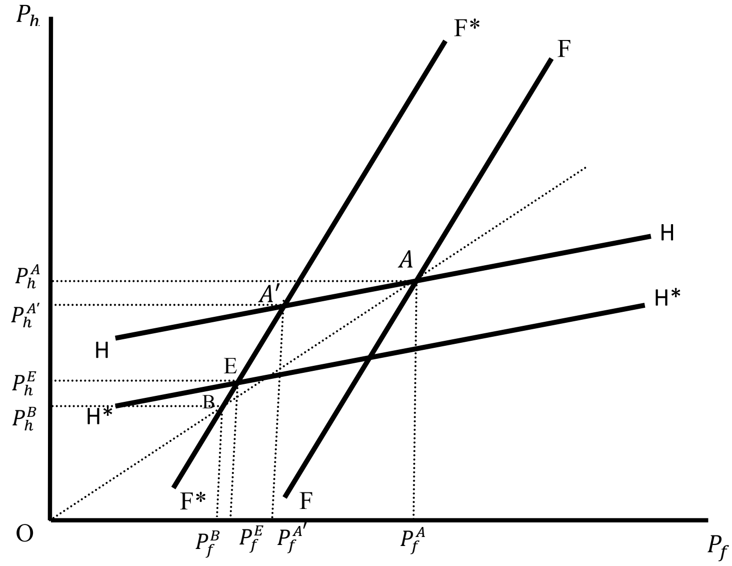
As a result of equation 2.42, at A' the relative price of domestic products has increased compared to A as can be seen by the slope of a ray through A' compared to OR. Based on equations 2.41 and 2.42, we can conclude that the exchange rate pass-through (ERPT) to domestic prices is less than one.

$$\tau_h = \frac{\frac{P_h^A P_h^{A'}}{OP_h^A}}{\frac{de}{e}} = \frac{\frac{dP_h}{P_h}}{\frac{de}{e}} = \tau_f \frac{\frac{dP_h}{P_h}}{\frac{dP_f}{P_f}} < 1 \tag{2.43}$$

Now, consider the case that the intermediate materials are imported: $P_{mat.h} = P_{mat.f} \times e$. In this case, as shown in Figure 2.3, an appreciation of the domestic currency will shift the foreign reaction function to the left (from FF to F^*F^*) while shifting the home country's reaction function to the right (from HH to H^*H^*). The magnitude of the shift in HH at given relative prices should be less than the shift in FF because the decrease in the foreign firm's cost is proportional to appreciation while it only decreases the cost of intermediate materials for home firms. Therefore, we expect that the equilibrium point should be between A' and B. In fact, the appreciation generates a greater cost advantage for the foreign firm than the domestic producer and therefore it is reasonable to expect that the the relative price of the domestic products increases at the new equilibrium. In general, relative to the case that $P_{mat.h}$ is independent of the exchange rate, the exchange rate pass-through to the foreign and home producer prices is higher but still less than one.

Figure 2.3 is similar to Figure 2.2 except that the home country's reaction function has been shifted to the right. Point E shows the new equilibrium. Based on equation 2.40 $\frac{P_f^A P_f^B}{OP_f^A} < \frac{de}{e}$, we can conclude that $\frac{P_f^A P_f^E}{OP_f^A} < \frac{de}{e}$ and therefore the ERPT to the foreign firm's

Figure 2.3: The Effects of an Appreciation of the Domestic Currency When Materials Are Imported



price (τ_f) is less than one. However, in this case, the ERPT to the foreign firm's price is higher than the case that $P_{mat.h}$ is independent of the exchange rate because $\frac{P_f^A P_f^{A'}}{OP_f^A} < \frac{P_f^A P_f^E}{OP_f^A}$. Since at E the relative price of the domestic products has increased, we can conclude that the percentage changes in the domestic producer price is less than the percentage changes in the foreign firm's price. Therefore, the ERPT to the domestic producer price is also less than one but higher than the case that $P_{mat.h}$ is independent of the exchange rate because $\frac{P_h^A P_h^{A'}}{OP_h^A} < \frac{P_h^A P_h^E}{OP_h^A}$.

Determinants of Exchange Rate Pass-Through By totally differentiating the equations 2.34 and 2.35, we are able to derive specifically the elasticity of the domestic producer price with respect to the exchange rate (ERPT to the domestic producer price) as follow (see the Appendix C):

$$\tau_h = \frac{\frac{dP_h}{P_h}}{\frac{de}{e}} = \frac{1 - \mu\beta(\frac{\xi_h}{\delta s_h})(1 - \omega\xi_f - \frac{\delta S_f}{\xi_f})}{(1 - \omega\xi_f + (1 - \omega\xi_f - \frac{\delta S_f}{\xi_f})(-\omega\xi_h + 1)(-\frac{\xi_h}{\delta s_h}))} < 1 \tag{2.44}$$

where $\delta = (\varepsilon - 1) > 0$, μ is the elasticity of domestic production costs with respect to the price of intermediate materials and considering that intermediate materials cost is a fraction of production costs, it should be less than one ($\mu < 1$), $\beta \leq 1$ is the extent of exchange rate pass-through to domestic price of intermediate materials, and ω is the elasticity of marginal cost with respect to output, which is assumed to be positive and the same for both the domestic and the foreign firms. Considering that $\mu\beta < 1$, $\xi_f, \xi_h < 0$, and $\omega > 0$, the ERPT to the domestic producer price (τ_h)is less than one. AS equation 2.44 implies, the magnitude of the ERPT to the domestic producer price is affected by four factors: the elasticity of domestic production cost with resect to exchange rate ($\mu\beta$), the elasticity of marginal cost with resect to output (ω), the measure of substitutability among the variants(δ) and the domestic or foreign firms' market share (S_h or S_f). Specifically (see the Appendix C),

$$\frac{d\tau_h}{d\mu\beta} > 0 \tag{2.45}$$

$$\frac{d\tau_h}{d\omega} < 0 \tag{2.46}$$

$$\frac{d\tau_h}{d\delta} \gtreqless 0 \tag{2.47}$$

$$\frac{d\tau_h}{dS_h} > 0 \tag{2.48}$$

As an contribution to the literature, this model clearly shows that there is a positive relationship between the ERPT and the elasticity of domestic production cost with resect to exchange rate ($\mu\beta$).[1] An increase in this elasticity ($\mu\beta$) means that changes in domestic production costs will increase as a result of a given amount of the appreciation or depreciation of the domestic currency and therefore as equation 2.36 shows, the domestic price would be affected more by exchange rate changes, given other factors constant.

There is a negative relationship between the ERPT to the domestic producer price and the elasticity of marginal cost with respect to output. Everything else held constant, an appreciation of the domestic currency tends to decrease the foreign firm's price in the domestic currency, which in turn will increase demand for the foreign firm's products. Based on our assumption that the elasticity of marginal cost with respect to output is positive, an increase in output will lead to increase in marginal cost and tend to increase the foreign firm's price in domestic currency. Thus, the higher the elasticity of marginal cost with respect to output, the more the change in marginal cost will offset the effect of exchange rate movements on the foreign firm's price in the domestic market and consequently the ERPT to the foreign

[1] By assuming that the extent of exchange rate pass-through to domestic price of intermediate materials β is equal to one, and the share of intermediate materials in total production costs is a good measure for the elasticity of domestic production costs with respect to the price of intermediate materials, we can conclude that there is a positive relationship between the ERPT and the share of intermediate materials, as the tradable inputs, in total production costs.

firm's price is negatively related to the elasticity of marginal cost with respect to output. On the other hand, the reaction of the domestic producer price to changes in the foreign firm's price decreases as the elasticity of marginal cost with respect to output increases because the tendency of the domestic firms to decrease their price in response to decrease in the foreign firm's price is offset by higher production costs. Therefore, the ERPT to the domestic producer price is negatively related to the elasticity of marginal cost with respect to output. In Figure 2.2, the higher elasticity of marginal cost with respect to output will lead to smaller shift in FF and decrease in slope of HH. Consequently, the equilibrium point would be between A' and A which indicates lower ERPT to both domestic producer price and the foreign firm's price.

The relationship between the extent of ERPT to the domestic producer price and the degree of substitution among different variants in the industry is not clear. When products in the industry are highly substitutable, the demand elasticity facing the firm is relatively higher and consequently the markup would be lower. In this case, the appreciation of the domestic currency will provide the opportunity for the foreign firm to absorb this shock by increasing its profit margin rather than passing the shock to prices. Consequently the ERPT to the foreign firm's price is negatively related to the degree of substitution among different variants. On the other hand, the reaction of the domestic producer price to changes in the foreign firm's price increases as the degree of substitution among different variants increases because if the domestic producer does not decrease its price in response to decrease in the foreign firm's price, they will lose their customers. Considering that ERPT to the domestic producer price is equal to the ERPT to the foreign firm's price times the reaction of the domestic producer price to changes in the foreign firm's price (see equation C.11), the relationship between the extent of ERPT to domestic producer price and the degree of substitution among different variants in the industry could be positive or negative depending on the magnitude of the changes in these two factors. As it has been shown in the Appendix C (see equation C.15), as the demand price elasticity perceived by the domestic firms (ξ_h) increases and the demand price elasticity perceived by the foreign firms (ξ_f) as well as the elasticity of the domestic production costs with respect to exchange rate ($\mu\beta$) decrease, it is more likely that the degree of the ERPT to the domestic producer price to be positively affected by the degree of substitution among different variants in the industry.

As equation 2.44 indicates, there is a positive relationship between the ERPT to the domestic producer price and the market share of the domestic firm. The foreign firm with a smaller market share has incentive to decrease its price more as a result of the appreciation of the domestic currency to obtain more market share. In other words, there is an inverse relationship between the market share of foreign firms and the ERPT to the foreign firms' prices.[1] On the other hand, the domestic firm with a larger market share has a lower demand elasticity and consequently higher markup. In this case the domestic firm is more able to decrease its price in reaction to decrease in foreign firm's price as a result of the appreciation of the domestic currency. Therefore, the ERPT to the domestic producer price, which is equal to the ERPT to the foreign firm's price times the reaction of the domestic producer price to changes in the foreign firm's price, is positively related to the domestic firm's market share.

Now we continue the discussion regarding the effects of other factors (wages, price of intermediate materials, and domestic income) on the equilibrium prices of domestic and foreign variants in home country.

2.3.4.2 The Effects of Domestic and Foreign Wages

The effect of the decrease in W_f is similar to the effects of appreciation in Figure 2.2. The foreign firm's reaction function will shift up and to the left while leaving the home country's reaction function in place. Both P_f and P_h will decrease but the decrease in P_h is proportionally less than the decrease in P_f. Thus, the relative price of the domestic products will increase.

The effect of the increase in W_f is shown in Figure 2.4. The foreign reaction function will shift down and to the right (from FF to F^*F^*). Both P_f and P_h will increase but the increase in P_h is proportionally less than the increase in P_f. Consequently, the relative price of domestic products will decrease. The above explanations on the effects of W_f demonstrate that this variable affects P_f and P_h positively.

As shown in Figure 2.5, the decrease (increase) in W_h will decrease (increase) both P_f and P_h but the decrease (increase) in P_f is proportionally less than the decrease (increase)in P_h. Therefore, the relative price of the domestic products will decrease as shown in A' (increase as shown in A''). As it can be observed, W_h affects positively both P_f and P_h.

[1] A sufficient condition for the negative relationship between foreign firms' market share and the ERPT to the foreign firms' prices is that the marginal cost elasticity (ω) is smaller than or equal to the degree of product substitution (ε).

Figure 2.4: The Effects of an Increase in Wage in Foreign Country

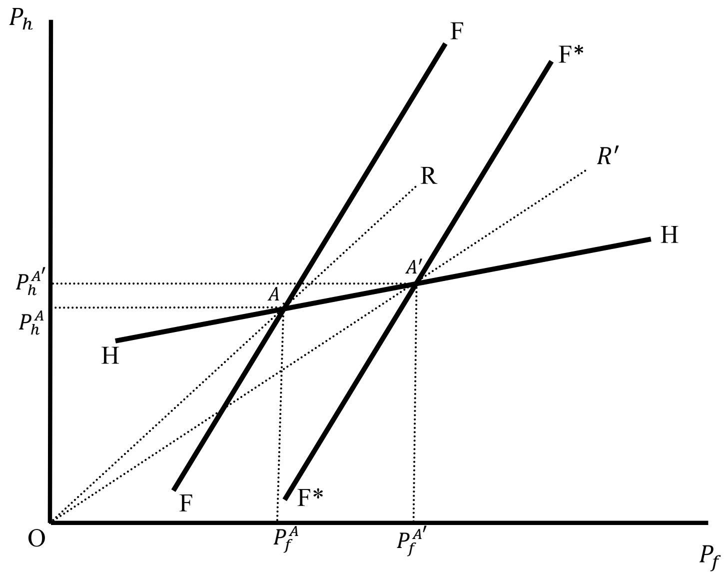
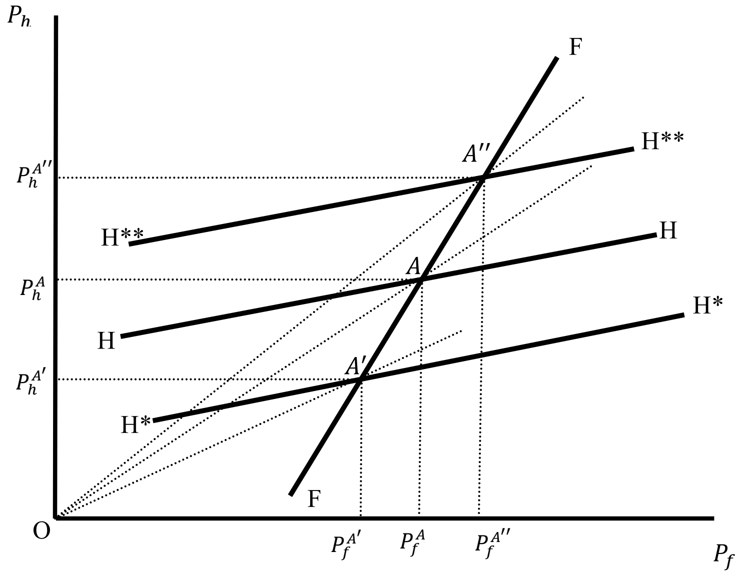


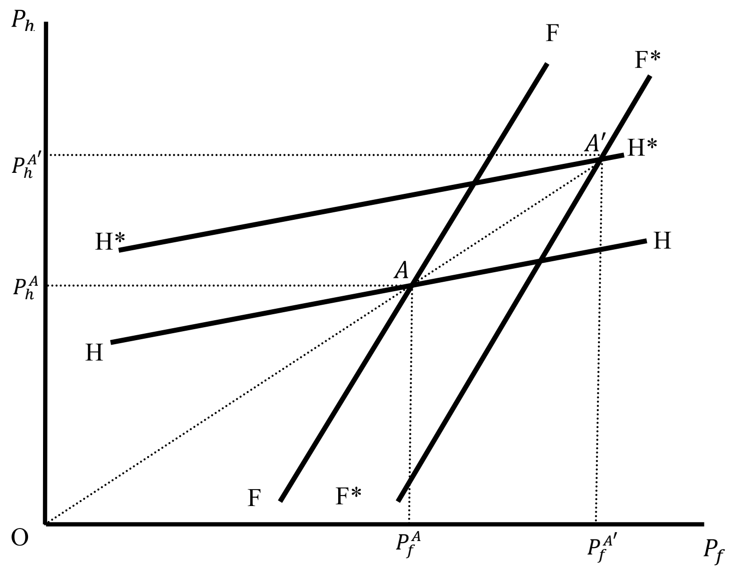
Figure 2.5: The Effects of a Decrease (an Increase) in Wage in Domestic Country



2.3.4.3 The Effects of Domestic Income and Price of Intermediate Materials

Based on equations 2.36 and 2.37, increase in income (E_X) and price of intermediate materials ($P_{mat.f}$) will shift the foreign reaction function to the right (from FF to F^*F^*) while shifting the home country's reaction function to the left (from HH to H^*H^*). As shown in Figure 2.6, in the new equilibrium (A'), both P_f and P_h will increase but by assuming that the magnitude of the shifts in reaction functions are equal, the relative price of the domestic products would remain unchanged. On the other hand, decrease in income (E_X) and price of intermediate materials ($P_{mat.f}$) will lead to decrease in both P_f and P_h while again the relative price of the domestic products would remain unchanged (consider the shift from A' to A).

Figure 2.6: The Effects of an Increase in Domestic Income and Price of Intermediate Materials



Generally, based on the equations 2.36 and 2.37 as well as the provided explanations about the effects of different variables on P_h and P_f we have (considering that the parameters ε, n_h and n_f are constant in each industry):

$$P_h = P_h(W_f^+, P_{mat.f}^+, W_h^+, E_X^+, e^+) \tag{2.49}$$

$$P_f = P_f(W_f^+, P_{mat.f}^+, W_h^+, E_X^+, e^+) \tag{2.50}$$

where (+) indicates the positive relationship. These equations indicate that both the domestic producer price and the foreign firm's price are positively affected by wages and prices of intermediate materials in both countries as well as exchange rate and domestic income.

The provided theoretical framework enables us to follow a two-stage procedure for estimation of the exchange rate pass-through and its determinants. By estimating the equation 2.49 in logarithm form for each industry, the exchange rate pass-through to domestic producer price (the coefficient of exchange rate) is obtained for each industry. Then, the second stage explains the determinants of the exchange rate pass-through by regressing the estimated coefficients for exchange rate pass-through on the factors derived in the theoretical framework such as the elasticity of domestic production cost with resect to exchange rate, the elasticity of marginal cost with resect to output, the degree of substitutability among the variants and the domestic or foreign firms' market share.

2.4 Summary and Conclusions

The significant appreciation/depreciation of the Canadian dollar in recent years has created great interest in the effects of these changes on the Canadian economy. Examining the exchange rate pass-through (ERPT), which indicates the extent that Canadian output and input prices are affected by the exchange rate changes, can shed some light in this issue. The rate of the ERPT has important implications for the volatility of the real exchange rate as well as the effectiveness of the trade and monetary policies. Moreover, the exchange rate pass-through estimations help us to identify and understand those markets which are more at risk from large variations in exchange rates, which in turn can help in designing appropriate policies.

The purpose of the study on the ERPT in this thesis is to model and estimate the extent of exchange rate pass-through to domestic producer prices and its determinants for the Canadian manufacturing industries at three and four-digit levels of NAICS. However, to examine the theoretical and empirical aspects of exchange rate pass-through and its determinants, the study is organized in two separate theoretical and empirical chapters. This chapter as a theoretical paper provided an extensive literature review and contributed to the literature by developing a relatively more general theoretical framework.

In this chapter, section 2.2 was allocated to the review of the theoretical and empirical literature on exchange rate pass-through. In addition to a discussion about the law of one price (LOP) which predicts that exchange rate pass-through should be equal to one, the theoretical literature review tried to explain why exchange rate pass-through could be less than one and different across sectors. Some factors such as market structure, different demand elasticities in the import and export markets, multinational enterprises, non-tariff barriers and pricing to market (PTM) were discussed as the related reasons. In the review of empirical studies, the major empirical studies were discussed particularly in terms of their model structure, contribution and weakness. In addition to providing a reference to compare our findings, this review helps us in considering the related variables and choosing the appropriate measures for them. The literature suggests that the estimation of ERPT for manufacturing industries and primary products (such as agricultural products) requires two different theoretical frameworks and therefore model specifications. Primary products are goods which the products of different countries are close to identical, or near-perfect substitutes, and therefore the LOP could be expected but this does not hold for manufactured products.

The theoretical framework for estimation of the ERPT in manufacturing industries was presented in Section 2.3. This model contributed to the literature by developing a relatively general model which is able to show all the major determinants of exchange rate pass-through together, while the previous studies have only analyzed the role of one or some of these factors. We considered the domestic market for differentiated products, which belong to a well-defined industry category but imperfect substitutes for each other in the eyes of consumers, such as automobiles. We assumed that some of the varieties are produced domestically, while others are imported. We also assumed that the individual firm is sufficiently large to affect industry price and firms respond to changes in industry price. Moreover, it was assumed that the marginal cost is increasing and is affected by the wage rate and the price of the intermediate materials (which are considered as the tradable inputs) in addition to the production level. By solving this model, it was specifically shown that exchange rate pass-through should be between zero and one, while it is positively affected by the share of intermediate materials, as the tradable inputs, in production costs, and the domestic firms' market share and negatively by the elasticity of marginal cost with respect to output. The sign for the degree of substitutability among the variants is not theoretically clear and remains as an empirical question.

The provided theoretical framework will be applied in Chapter 3 as the base for estimation of the exchange rate pass-through and its determinants in Canadian manufacturing industries.

Appendix C

Derivation of the Equations for Theoretical Framework

By modifying the equations 2.34 and 2.35, we have:

$$P_h(1+\frac{1}{\xi_h}) = C'_{X_h}(X_h, W_h, P_{mat.h}(e)) \tag{C.1}$$

$$P_f(1+\frac{1}{\xi_f}) = C'_{X_f}(X_f, W_f, P_{mat.f})e \tag{C.2}$$

By totally differentiating the above equations, we have (considering that we are looking for the ERPT to domestic producer price, other variables such as W_h, W_f and $P_{mat.f}$ are treated as constant):

$$dP_h(1+\frac{1}{\xi_h}) + P_h(\frac{-d\xi_h}{\xi_h^2}) = C''_{X_h}(X_h, W_h, P_{mat.h}(e))dX_h + \frac{\partial C'_{X_h}}{\partial P_{mat.h}}.\frac{\partial P_{mat.h}}{\partial e}d(e) \tag{C.3}$$

$$dP_f(1+\frac{1}{\xi_f}) + P_f(\frac{-d\xi_f}{\xi_f^2}) = de.C'_{X_f}(X_f, W_f, P_{mat.f}) + e.C''_{X_f}(X_f, W_f, P_{mat.f})dX_f \tag{C.4}$$

Now, we should find $d\xi_h$ and $d\xi_f$. From equations 2.26, 2.28 and 2.29 we have:

$$\xi_h = -\varepsilon + (\varepsilon - 1)S_h = -\varepsilon + (\varepsilon - 1)\frac{1}{1+(\frac{n_f}{n_h})(\frac{P_h}{P_f})^{\varepsilon-1}}$$

Therefore,

$$d\xi_h = (\varepsilon - 1)\frac{-(\frac{n_f}{n_h})(1-\varepsilon)P_f^{-\varepsilon}P_h^{\varepsilon-1}dP_f - \frac{n_f}{n_h}(\varepsilon-1)P_f^{1-\varepsilon}P_h^{\varepsilon-2}dP_h}{(1+(\frac{n_f}{n_h})(\frac{P_h}{P_f})^{\varepsilon-1})^2}$$

$$d\xi_h = (\varepsilon-1)^2((\frac{1}{S_h}-1)\frac{dP_f}{P_f} - (\frac{1}{S_h}-1)\frac{dP_h}{P_h})S_h^2 = (\varepsilon-1)^2 S_h(1-S_h)(\frac{dP_f}{P_f} - \frac{dP_h}{P_h})$$

$$d\xi_h = (\varepsilon-1)^2 S_h S_f(\frac{dP_f}{P_f} - \frac{dP_h}{P_h}) \tag{C.5}$$

Similarly for ξ_f we have:

$$d\xi_f = (\varepsilon-1)^2 S_f S_h(\frac{dP_h}{P_h} - \frac{dP_f}{P_f}) \tag{C.6}$$

By substituting C.5 in C.3 we have:

$$\begin{aligned} dP_h(1+\frac{1}{\xi_h}) + P_h(-\frac{(\varepsilon-1)^2 S_h S_f(\frac{dP_f}{P_f} - \frac{dP_h}{P_h})}{\xi_h^2}) &= C''_{X_h}(X_h, W_h, P_{mat.h}(e))dX_h + \\ &\quad \frac{\partial C'_{X_h}}{\partial P_{mat.h}}.\frac{\partial P_{mat.h}}{\partial e}d(e) \end{aligned}$$

By multiplying both sides of the above equation by $\frac{X_h}{dX_h P_h}$, we have:

$$\begin{aligned} \frac{1}{\xi_h}(1+\frac{1}{\xi_h}) + \frac{X_h}{dX_h}(-\frac{(\varepsilon-1)^2 S_h S_f(\frac{dP_f}{P_f} - \frac{dP_h}{P_h})}{\xi_h^2}) &= \omega\frac{C'_{X_h}}{P_h} + \mu\beta\frac{C'_{X_h}}{P_h}\frac{X_h}{dX_h}\frac{de}{e} = \\ &\quad \omega(1+\frac{1}{\xi_h}) + \mu\beta(1+\frac{1}{\xi_h})\frac{1}{\xi_h \tau_h} \end{aligned}$$

where $\omega = \frac{\partial C'_{X_h}}{\partial X_h}\frac{X_h}{C'_{X_h}}$ is the elasticity of marginal cost with respect to output, $\mu = \frac{\partial C'_{X_h}}{\partial P_{mat.h}}\frac{P_{mat.h}}{C'_{X_h}}$ is the elasticity of domestic marginal cost with respect to domestic price of intermediate materials, $\beta = \frac{\partial P_{mat.h}}{\partial e}\frac{e}{P_{mat.h}}$ is the elasticity of exchange rate pass-through to domestic price of the intermediate materials and $\tau_h = \frac{\frac{dP_h}{P_h}}{\frac{de}{e}}$ is the elasticity of the exchange rate pass-through to the domestic producer price. By considering that $\frac{X_h}{dX_h} = \frac{1}{\xi_h}\frac{P_h}{dP_h}$, from the above equation we have:

$$-(\varepsilon-1)^2 S_f S_h(\frac{\frac{dP_f}{P_f}}{\frac{dP_h}{P_h}}) = (\xi_h+1)(\omega\xi_h + \frac{\mu\beta}{\tau_h} - 1)\xi_h \tag{C.7}$$

Based on equation C.7 we have:

$$(\frac{\frac{dP_h}{P_h}}{\frac{dP_f}{P_f}}) = \frac{1}{1 - \frac{(\xi_h+1)(\omega\xi_h + \frac{\mu\beta}{\tau_h} - 1)\xi_h}{(\varepsilon-1)^2 S_f S_h}} \tag{C.8}$$

Now, we consider the second differentiated equation. By substituting equation C.6 in C.4 we have:

$$\begin{aligned} dP_f(1+\frac{1}{\xi_f}) + P_f(\frac{-(\varepsilon-1)^2 S_f S_h(\frac{dP_h}{P_h} - \frac{dP_f}{P_f})}{\xi_f^2}) &= de.C'_{X_f}(X_f, W_f, P_{mat.f}) + \\ &\quad e.C''_{X_f}(X_f, W_f, P_{mat.f})dX_f \end{aligned}$$

By multiplying both sides of the above equation by $\frac{e}{de.P_f}$, we have:

$$\tau_f(1+\frac{1}{\xi_f}-\frac{(\varepsilon-1)^2 S_f S_h(\frac{\frac{dP_h}{P_h}}{\frac{dP_f}{P_f}}-1)}{\xi_f^2}-\omega\xi_f(1+\frac{1}{\xi_f}))=1+\frac{1}{\xi_f} \tag{C.9}$$

where $(\tau_f=\frac{\frac{dP_f}{P_f}}{\frac{de}{e}})$ is the ERPT to the foreign firm's price. Considering that $(1+\frac{1}{\xi_f}=\frac{-\delta S_h}{\xi_f})$ and $(1+\frac{1}{\xi_h}=\frac{-\delta S_f}{\xi_h})$ and substituting C.8 in C.9 we have:

$$\tau_f(\frac{-\delta S_h}{\xi_f}-\frac{(\xi_h+1)(\omega\xi_h+\frac{\mu\beta}{\tau_h}-1)\xi_h}{1-\frac{(\xi_h+1)(\omega\xi_h+\frac{\mu\beta}{\tau_h}-1)\xi_h}{(\varepsilon-1)^2 S_f S_h}}\frac{1}{\xi_f^2}+\frac{\omega\xi_f\delta S_h}{\xi_f})=\frac{-\delta S_h}{\xi_f}$$

By dividing both sides of the above equation by $\frac{-\delta S_h}{\xi_f}$, we have:

$$\tau_f=\frac{1}{(1-\omega\xi_f-\frac{\delta S_f}{\xi_f}(\frac{\xi_h(1-\omega\xi_h-\frac{\mu\beta}{\tau_h})}{\xi_h(1-\omega\xi_h-\frac{\mu\beta}{\tau_h})-\delta S_h}))} \tag{C.10}$$

Based on equation C.8, we can write:

$$(\frac{\frac{dP_h}{P_h}}{\frac{dP_f}{P_f}})=\frac{1}{1-\frac{(\xi_h+1)(\omega\xi_h+\frac{\mu\beta}{\tau_h}-1)\xi_h}{(\varepsilon-1)^2 S_f S_h}}=\frac{\tau_h}{\tau_f} \tag{C.11}$$

Based on the the equations C.10 and C.11, we can drive the ERPT to the domestic producer price (τ_h) as follows:

$$\tau_h=\frac{\frac{dP_h}{P_h}}{\frac{de}{e}}=\frac{1-\mu\beta(\frac{\xi_h}{\delta s_h})(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})}{\big(1-\omega\xi_f+(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})(-\omega\xi_h+1)(-\frac{\xi_h}{\delta s_h})\big)}<1 \tag{C.12}$$

Regarding the sign of the relationship between the ERPT to the domestic producer price (τ_h) and the parameters $(\mu\beta,\omega,\delta,S_f)$, from equation C.12 we have:

$$\frac{\partial\tau_h}{\partial(\mu\beta)}=\frac{-(\frac{\xi_h}{\delta s_h})(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})}{(1-\omega\xi_f+(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})(-\omega\xi_h+1)(-\frac{\xi_h}{\delta s_h}))}>0 \tag{C.13}$$

$$\frac{\partial\tau_h}{\partial\omega}=\frac{\frac{\xi_h\mu\beta S_f}{s_h}+(\xi_h(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})(-\frac{\xi_h}{\delta S_h})+\xi_f+\xi_f(-\omega\xi_f+1)(-\frac{\xi_h}{\delta S_h}))-\frac{\mu\beta\xi_h^2}{\delta S_h}(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})^2(-\frac{\xi_h}{\delta S_h})}{(1-\omega\xi_f+(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})(-\omega\xi_h+1)(-\frac{\xi_h}{\delta s_h}))^2}<0 \tag{C.14}$$

$$\frac{\partial \tau_h}{\partial \delta} = \frac{\frac{\xi_h}{\delta^2 s_h}(1-\omega\xi_f)(\mu\beta(1-\omega\xi_f)-(-\omega\xi_h+1))}{(1-\omega\xi_f+(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})(-\omega\xi_h+1)(-\frac{\xi_h}{\delta s_h}))^2} \tag{C.15}$$

Note that if $\frac{-\omega\xi_h+1}{-\omega\xi_f+1} \gtreqless \mu\beta$, then $\frac{\partial \tau_h}{\partial \delta} \gtreqless 0$.

$$\frac{\partial \tau_h}{\partial S_h} = \frac{(\frac{\xi_h}{\delta s_h}(-\frac{\delta}{\xi_f}+(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})\frac{1}{S_h})).(\mu\beta-1)(1-\omega\xi_f)}{(1-\omega\xi_f+(1-\omega\xi_f-\frac{\delta S_f}{\xi_f})(-\omega\xi_h+1)(-\frac{\xi_h}{\delta s_h}))^2} > 0 \tag{C.16}$$

Chapter 3

Estimation of Exchange Rate Pass-Through and Its Determinants in Canadian Manufacturing Industries

3.1 Introduction

By applying the provided theoretical framework in Chapter 2 to the Canadian and U.S. economies (Canada and U.S. are considered as domestic and foreign countries respectively), this chapter provides an empirical framework for estimation of exchange rate pass-through and its determinants in Canadian manufacturing industries using a two-stage procedure. After model specification and data description in section 3.2, the ERPT to the domestic producer price is estimated in subsection 3.3.1 for more than 100 Canadian manufacturing industries at three, four, and (a few cases of) five digit levels of NAICS using equation 2.49. An error correction model (ECM) is used to estimate contemporaneous and short run pass-through elasticities, while the long run pass-through elasticities are derived from the cointegration equations. Based on the theoretical framework, the hypothesis is that the ERPT should be between zero and one.

In the second stage, the variation of the ERPT among industries is explained in subsection 3.3.2 by regressing the estimated pass-through elasticities on the variables that are supposed to affect the pass-through elasticities according to the model developed in the previous chapter (see equations 2.45-2.48). The expectation is that there is a positive relationship between the magnitude of the ERPT to the domestic producer price and the elasticity of domestic marginal cost with respect to exchange rate, and the domestic firms' market share, while the magnitude of the ERPT is negatively affected by the elasticity of marginal cost with respect to output. The sign for the degree of substitutability among the variants is not theoretically clear and remains as an empirical question. Finally, a summary and conclusions of both theoretical and empirical chapters are presented in section 3.4.

3.2 Model Specification and Data

As equation 2.49 suggests, the Canadian producer price is positively affected by the wages and the price of intermediate materials in the U.S., the domestic wages; a measure of shift in demand, and the exchange rate between U.S. and Canadian dollars. Considering that the wages and the price of intermediate materials in the U.S. are not available at 3 or 4 digit NAICS industries, we use *total unit cost index* (TUCI) in U.S. to capture their effects.[1] By including this variable in the equation, the model will have a measure for cost in exporting country as it has been applied in the standard models of exchange rate pass-through (see Goldberg and Knetter, 1997). As a measure of shift in domestic demand, we use both GDP (as it has been applied by Feinberg, 2000 and Yu, 2007) and the capacity utilization in Canada (as it has been used by Hooper, 1989) and report the model with better results. Moreover, as mentioned in the literature (Hooper, 1989; Yang, 1997), although the model is static in nature, it is unlikely that there is only a once and for all effect of exchange rate changes on prices. Therefore, a lagged dependent variable is also included in the model and the lag length is determined base on the AIC. Thus, the model for exchange rate pass-through can be specified as follows:

$$\begin{aligned} log(P_{k,t}^{CAN}) &= \alpha_k + \beta_{1,k} log(TUCI_{k,t}^{U.S.}) + \beta_{2,k} log(W_{k,t}^{CAN}) + \beta_{3,k} log(GDP_t^{CAN}) + \beta_{4,k} log(e_t) \\ &+ \sum_{i=1}^{n} \lambda_{i,k} log(P_{k,t-i}^{CAN}) + \epsilon_{k,t} \end{aligned} \tag{3.1}$$

where $P_{k,t}^{CAN}$ is the Canadian producer price in industry k, $TUCI_{k,t}^{U.S.}$ represents total unit cost index in the U.S. for industry k, $W_{k,t}^{CAN}$ shows the Canadian wages in industry k, GDP_t^{CAN}

[1] Wage data are available for different groups of workers but not as aggregate. Total unit cost index is constructed using the total costs data and output index reported by U.S. Bureau of Labor Statistics.

is the gross domestic product in Canada, e_t shows exchange rate, and α_k and $\epsilon_{k,t}$ are constant and disturbance term for industry k, respectively.[1] Based on the theoretical framework, it is expected that the sign of all coefficients be positive. In this specification, $\beta_{4,k}$ shows the extent of exchange rate pass-through which is expected to be positive and less than one (partial pass-through) or in the extreme cases be equal to one (complete pass-through) or zero (zero pass-through).

As we know, if the variables are not stationary in levels, the standard asymptotic distribution theory often does not apply to regressions involving such variables and therefore the usual inference would not be valid if this is ignored. The Augmented Dickey-Fuller (ADF) test for unit roots shows that, with few exceptions, all the industry level variables included in the above equation contain unit roots (see Table D.1 in Appendix D).[2] Then we did test whether the variables (in an equation with intercept and trend) are co-integrated or not based on the unit root in residuals using ADF criteria.[3] However, as Maddala and Kim (1998) pointed out (see chapter 6 of their book), the critical values are not same as before because the tests are applied to the estimated residuals instead of the actual residuals. In this case, the critical values will depend on the number of the regressors in the original equation and whether a constant and/or a time trend is included in the equation.

MacKinnon (1991) provides an approximation formula for computing the critical values for all sample sizes T (see Maddala and Kim (1998), chapter 6, Pages 199-201). According to the calculated critical values for our sample based on this formula, except for few cases which can be found in the reported results in Table D.1 in Appendix D, we fail to reject the null hypothesis of unit root in residuals.[4] Then, we follow a bootstrap procedure to find more accurate critical values and p-values that indicate to what extend the test results are in favour of cointegration.[5] As the reported results in Table D.1 in Appendix D indicate, the p-values are between 1% and 10% for 21 industries, between 10% and 20% for 28 industries, between 20% and 30% for 25 industries, between 30% and 40% for 17 industries and more than 40% just for 14 industries. These results imply that, for most of the industries, the test results are highly in favour of cointegration, although the level of significance is outside the range

[1]In some models, GDP is replaced by the capacity utilization in Canada depending on the performance of these variables as the measures for the shift in demand.

[2]Considering that variables are likely trending (like GDP, price indices, cost indices), the unit root test is specified with intercept and trend. Moreover, the lag length is chosen based on the AIC.

[3]Here, the unit root test is specified without intercept and trend. Moreover, the lag length is determined based on the AIC.

[4]The critical values at 10, 5, and 1 percent significance level are -4.65, -5.00, -5.69 respectively.

[5]See the structure of the program in Appendix F.

of standard practice. Thus, it is reasonable to conclude that the variables are cointegrated, except for the industries that their p-values are greater than 40%. Consequently, to have the long- and short-run pass-through elasticities, we can estimate the cointegration equation as well as the error correction model (ECM), which has the ability to capture the short-term dynamics, as follows[1]:

$$\begin{aligned} \Delta log(P_{k,t}^{CAN}) &= \alpha'_k + \beta'_{1,k}\Delta log(TUCI_{k,t}^{U.S.}) + \beta'_{2,k}\Delta log(W_{k,t}^{CAN}) + \beta'_{3,k}\Delta log(GDP_t^{CAN}) \\ &+ \beta'_{4,k}\Delta log(e_t) + \sum_{i=1}^{n}\lambda'_{i,k}\Delta log(P_{k,t-i}^{CAN}) - \rho_k(log(P_{k,t-1}^{CAN}) - \alpha_k - \beta_{1,k}log(TUCI_{k,t-1}^{U.S.}) \\ &- \beta_{2,k}log(W_{k,t-1}^{CAN}) - \beta_{3,k}log(GDP_{t-1}^{CAN}) - \beta_{4,k}log(e_{t-1})) + \epsilon'_{k,t} \end{aligned} \tag{3.2}$$

Where Δ shows the first difference, ρ_k describes the speed of adjustment back to long-run equilibrium in industry k and it is expected to be positive. The expression written after ρ_k indicates the equilibrium error in $t-1$ obtained from the co-integration relationship. This equation, as well as the long-run relationship, are estimated for 3 and 4 digit (and few cases for 5 digit) NAICS industries which their comparable data in the U.S. and Canada are available (more than 100 industries) using quarterly data from the first quarter of 1992 to the second quarter of 2007.[2] The estimation of the exchange rate pass-though at 3 and 4 digit levels of NAICS gives the opportunity to compare the result at different levels of aggregation.

The U.S. Bureau of Labor Statistics (BLS) provides the data for constructing total unit cost index in the U.S. (the total costs data and output index), while the Canadian data have been obtained from the CANSIM.[3]

The second stage regression model is specified based on the provided theoretical framework in which it was shown that the the magnitude of the ERPT to the domestic producer price is affected by four factors: the degree of substitutability among the variants, the foreign firms'

[1]We have also reported the results of the first difference model for the case that the reader is not convinced that the variables are cointegrated because, for many industries, the level of significance is outside the range of standard practice (see Table D.2 in Appendix D).

[2]In estimation of the models, we should note that: (a) All variables are seasonally adjusted and in real terms (except for exchange rate). The U.S. and Canadian nominal variables have been converted to the real using implicit price indices in the U.S. and Canada respectively. (b) Although in finding the cointegration relationships we use equation 3.1 after including trend, for finding the long-run coefficients and residuals we use dynamic OLS (recommended by Stock and Watson, 1993) in which we also include the leads and lags of the first difference of the right hand side variables into the equation. (c) Although it is reasonable to have a productivity measure in the equation, we do not have this measure as quarterly in 3 and 4 digit level of NAICS. The appropriate proxy may be the quarterly productivity index for total economy. However, there is a high degree of collinearity between this variable and the real GDP as one of the explanatory variables. Therefore, we decide to not include this variable into the equation.

[3]See the sources of data in Appendix E.

market share, the elasticity of domestic marginal cost with resect to exchange rate, and the elasticity of marginal cost with resect to output.[1] Considering these factors, we have:

$$\beta'_{4,k} = c_0 + c_1 IIT_k + c_2 SIM_k + c_3 SMAT_k + c_4 KLR_k + \epsilon_k \tag{3.3}$$

Intra-industry tarde index IIT_k is the variable measuring the degree of product differentiation for industry k. Based on the intra-industry trade literature, the extent of intra-industry trade is positively related to the degree of product differentiation. IIT index is defined as follows:

$$IIT_k = 1 - \frac{\mid X_k - M_k \mid}{X_k + M_k}$$

where X_k and M_k are the values of exports and imports in industry k, respectively. Based on the provided theoretical discussions, the sign of this variable is not clear in prior. It depends on whether the positive relationship between ERPT to the foreign firm's price and the degree of product differentiation is offset by the negative relationship between the reaction of the domestic producer price to changes in the foreign firm's price and the degree of product differentiation.

SIM_k is the measure for the American firms' market share in industry k in Canada which is defined as the ratio of the imports from U.S. in industry k to supply in industry k by Canadian and American firms. The estimated coefficient for this variable, c_2, is expected to be negative i.e. the higher the import share, the smaller the pass-through. $SMAT_k$ is the proxy for the elasticity of domestic marginal cost with respect to domestic price of intermediate materials that are considered as tradable inputs. This variable is defined as the share of the intermediate materials in production costs in industry K. According to the provided theoretical model, it is expected that c_3 to be positive.

Capital to labour ratio in industry k, KLR_k is the proxy for the elasticity of marginal cost with respect to output. Bils and Chang (2000) theoretically show, using a CES production function, and empirically confirm, based on the observations on 458 4-digit SIC manufacturing industries in U.S., that there is a negative relationship between the growth rate of Capital to labour ratio and the growth rate of the marginal cost. Considering that the provided theoretical framework predicts that there is a negative relationship between the elasticity of

[1] The elasticity of domestic marginal cost with resect to exchange rate is equal to the elasticity of domestic marginal cost with respect to domestic price of intermediate materials if we assume that the exchange rate pass-through to the domestic price of intermediate materials, as the tradable inputs, is equal to one.

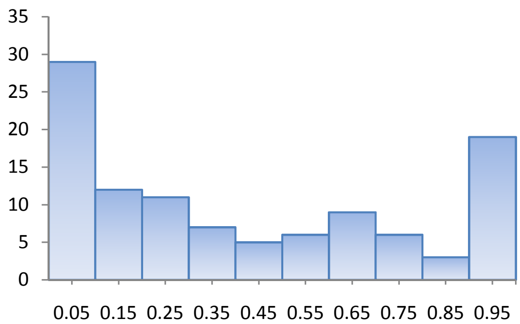
marginal cost with respect to output and the pass-through, it is expected that the estimated coefficient for Capital to labour ratio to be positive.

3.3 Estimation Results and Discussion

3.3.1 Exchange Rate Pass-Through Estimations

Estimation results of equation 3.2 as well as the long-run relationship for individual industries are reported in Table 3.1 and Table 3.2 respectively. Before focusing on the estimates of the exchange rate pass-through as the variable we are interested in, it is useful to examine the estimates of the other variables. With few exceptions, the estimated coefficients for these variables (capacity utilization, GDP and wage in Canada as well as U.S. cost) in error correction model are positive which is consistent with the theoretical prediction.[1] Among them, the U.S. cost is the most important variable which affects the Canadian producer prices with the average of 0.45. For 71 of the 107 industries, this variable is statistically significant. Figure 3.1 represents the histogram of the estimated coefficients for this variable across industries.[2] Although this coefficient for the majority of industries (60 percent) is less than 0.40, it is high (more than 0.70) for the significant number of industries (27 industries).

Figure 3.1: Histogram of the Estimated Coefficients for the U.S. Cost



The capacity utilization and GDP in Canada, which are the measures for demand pressure, are much less important. The estimated coefficients of the capacity utilization are statistically significant for only 10 of the 44 industries and only for 11 of the 63 industries in the case of the

[1]Except for GDP coefficients in Other Leather [3169], Printing [32311], Electric Lighting Equipment [3351], Household Appliance [3352], and Motor Vehicle Parts [3363] and the U.S. cost coefficients in Dairy [315] and Clay [3271], negative coefficients are not statistically significant.

[2]The horizontal axis shows the range of the estimated coefficients for U.S. cost and the vertical axis shows the number of industries.

GDP estimates. The estimated coefficients for capacity utilization and GDP are less than 0.10 in more than 35 and 57 industries respectively. The largest estimated coefficients for capacity utilization is 0.40 which belongs to Alumina and aluminum production and processing [3313] while the largest estimated coefficients for GDP is 0.24 which belongs to Paper mills [32212].

The wage in Canada is the least important variable. This variable is statistically significant for only 12 of the 107 industries. The estimated coefficient for this variable is less than 0.10 in 98 industries. The largest estimated coefficient is 0.53 which belongs to Veneer, plywood and engineered wood product manufacturing [3212].

Contemporaneous, short-run (after two quarters) and long-run estimations of exchange rate pass-through elasticities are presented in the second and eighteenth columns of Table 3.1 and the second column of Table 3.2 respectively.[1] Although 11 of the 107 industries have negative estimates for the contemporaneous pass-through elasticities, (Fruit and vegetable preserving [3114], Veneer, plywood and engineered wood product [3212], Other petroleum and coal products [32419], Clay product and refractory [3271], Glass and glass product [3272], Lime and gypsum product [3274], Non-ferrous metal (except aluminum) production and processing [3314], Pharmaceutical and medicine [3254], Soap, cleaning compound [3256], Plastic bottle [32616], and Office furniture [3372]) none of them is statistically different from zero even at the 10 percent significance level.[2] Seven industries show zero estimates for the contemporaneous pass-through elasticities: Bakeries and tortilla [3118], Beverage [3121], Wineries [31213], Textile furnishings mills [3141], Footwear [3162], Polystyrene [32615], Nonmetallic mineral [327].

Considering that the purpose of this stage of the study is to estimate the exchange rate pass-through elasticities to determine to what extent an appreciation or depreciation of the domestic currency can affect the price of the domestically produced products in the domestic market, the results clearly indicate that the prices of above industries are not much affected by exchange rate variations. While explaining the reasons of low pass-through in these industries needs a detail discussion regarding the market structure in each industry (such as the role of

[1]Regarding the short run estimates, it should be noted that the AIC has been considered as the measure for choosing the number of the dependent variable lags. Based on this measure, the maximum number of lags is two quarters.

[2]Given that the same regressions were run for all industries, it is perhaps not surprising that the results obtained are quite mixed. However, the results of this study, in general, are highly consistent with prior expectations in a way that only seven coefficients for GDP and U.S. costs have non-expected sign while are statistically significant. This feature shows the strength of the provided model. The similar studies in the case of Canada (such as Kardasz and Stollery, 2005) decided to drop significant number of industries (35 out of 72) from the analysis because of the statistically significant coefficients with non-expected sign or negative R^2.

the non-tariff barriers or a fraction of the market which is under control of the multinational enterprises) and is beyond the focus of this study, the provided theoretical discussion on the determinants of exchange rate pass-through may shed some light on this issue. Based on the theoretical considerations, low share of tradable inputs (intermediate materials) in production costs, high elasticity of marginal costs with respect to output, and high share of imports in domestic market may lead to very small exchange rate pass-through. For example, in the case of Bakeries and tortilla [3118], the share of tradable inputs (intermediate materials) in production costs is 0.46 (relative to 0.54 as the average of the sample), the capital to labour ratio as an inverse measure for the elasticity of marginal costs with respect to output is 0.08 (relative to 0.21 as the average of the sample), and the share of imports in domestic market is 0.12 (relative to 0.38 as the average of the sample), therefore the relatively low share of tradable inputs in production costs and high elasticity of marginal costs with respect to output are the likely reasons of low exchange rate pass-through in Bakeries industry.

Table 3.1: Contemporaneous and Short-Run Exchange Rate Pass-Through

Ind.	C-ERPT	t	U.S. Cost	t	Cap. Util.	t	GDP	t	Wage	t	Deviation	t	P(-1)	t	P(-2)	t	S-ERPT	R^2
311	0.13	3.24	0.57	6.39			-0.04	-0.97	0	0.12	0.22	2.8					0.13	0.54
3111	0.05	0.47	1.06	7.29			0	0.01	-0.1	-0.74	0.08	1.06					0.05	0.57
3112	0.38	4.09	0.75	7.39			0.05	0.57	-0.03	-0.28	0.18	2.13					0.38	0.62
3113	0.19	3.29	0.65	3.51	0.24	1.85			0.01	0.24	0.39	3.81	0.23	2.11			0.25	0.39
3114	-0.02	-0.03	0.06	0.73			0.04	1.3	0.03	0.82	0.26	2.96	0.28	1.99			-0.03	0.31
3115	0.02	0.68	-0.05	-2.34	-0.11	-1.6			-0.01	-0.28	0.12	1.7	0.07	0.58			0.02	0.15
3116	0.37	3.69	0.66	7.93			-0.09	-0.97	-0.04	-0.33	0.49	4.12	0.16	1.75			0.44	0.61
3118	0	0.29	-0.03	-1.43	0	0			0.01	0.7	0.05	1.27	0.24	1.83			0.00	0.11
3121	0	0.35	0.19	1.89			0.01	0.41	-0.02	-0.83	0.03	0.73					0.00	0.09
31213	0	0.14	-0.09	-0.63			-0.02	-0.38	0.15	1.83	0.18	2.94					0.00	0.16
31214	0.35	9.41	-0.01	-0.12			0.01	0.62	0.02	0.5	0.17	1.71	0.02	0.22			0.36	0.68
313	0.08	4.18	0.58	4.37			-0.02	-1.27	0.04	2.22	0.14	2.4	0.18	1.68			0.10	0.49
3131	0.12	2.8	0.75	5.82			-0.04	-0.92	0.1	3	0.32	4.01	0.32	3.52			0.18	0.61
3132	0.06	2.81	0.33	2.04			-0.03	-1.35	0.02	1.14	0.13	2.43	0.13	1.12			0.07	0.3
3133	0.1	1.66	0.04	0.14			-0.04	-0.72	0.02	0.6	0.6	4.33					0.10	0.29
3141	0	0.1	0.48	2.75			0	-0.1	-0.02	-0.77	0.01	0.46					0.00	0.12
315	0.01	1.85	0.39	2.83	0	-0.76			0	-0.21	0.04	1.4	0.43	3.74			0.02	0.31
3151	0.02	1.56	0.04	0.51			0.01	0.56	0.03	2.03	0.09	1.75					0.02	0.12
3159	0.01	1.92	0.4	1.86			-0.01	-0.67	0.02	0.98	0	0.07	0.28	2.45			0.01	0.17
316	0.04	1.71	0	0	0	-0.2			0.01	0.79	0.09	2	0.35	2.79			0.06	0.24
3162	0	0	-0.22	-0.89			-0.01	-0.56	0	0.27	0.26	4.36	0.28	2.48			0.00	0.35
3169	0.03	0.7	0	0.19			-0.08	-1.91	0.01	0.14	0.05	0.82	0.32	2.12			0.04	0.16
321	0.31	2	1.34	2.86	-1.18	-1.2			0.16	0.59	0.42	3.71	-0.15	-2.23			0.27	0.8
3211	0.36	1.82	1.57	2.37	0.01	0.07			-0.07	-0.22	0.31	3.14	-0.16	-2.39			0.31	0.77
3212	-0.1	-0.44	0.97	9.53	0.14	0.69			0.53	1.51	0.38	3.7					-0.10	0.64
3219	0.22	4.64	0.34	5.86	0	-0.1			0.04	0.74	0.32	4.01	0.19	2.08			0.27	0.56
322	0.52	5.6	1.07	9.8			0.16	1.8	0.11	0.8	0.22	2.3	0.1	1.29			0.58	0.83
32211	0.91	5.15	1.22	7.64	0.37	1.97			-0.32	-1.11	0.5	3.73					0.91	0.86
32212	0.7	9.72	1.01	12.75			0.24	3.59	-0.1	-1.03	0.18	3.31	0.19	3.38			0.86	0.9
32213	0.2	2.68	1.04	4	0.06	0.77			0.01	0.1	0.3	3.58					0.20	0.91

Table 3.1: Continued

Ind.	C-ERPT	t	U.S. Cost	t	Cap. Util.	t	GDP	t	Wage	t	Deviation	t	P(-1)	t	P(-2)	t	S-ERPT	R^2
3222	0.01	0.31	0.06	2.89			-0.09	-1.49	-0.05	-0.55	0.23	4.19	0.61	6.54			0.03	0.56
32311	0.29	4.19	0.14	2.28			-0.08	-2.26	0.05	0.9	0.14	3.52	0.68	8.21			0.91	0.68
32312	0.05	2.1	0.28	2.42	0.03	1.74			0	-0.14	0.13	2.25					0.05	0.2
324	0.65	5.52	0.8	2.83	0.01	0.1			0.01	0.12	0.68	5.63					0.65	0.93
32411	0.69	5.4	0.76	5.26	-0.01	-0.13			0.03	0.26	0.66	5.59					0.69	0.92
32412	0.27	1.64	1.29	4.89			0.21	1.29	-0.6	-0.83	0.37	3.36	0.39	2.93			0.42	0.63
32419	-0.09	-0.65	0.69	2.64	0.16	1.28			-0.25	-1.52	0.19	2.06	0.32	2.31			-0.13	0.32
325	0.2	3.16	1.41	8.65	0.02	0.34			-0.11	-0.95	0.23	3					0.20	0.61
3251	0.35	2.56	0.89	5.91	0.04	0.35			-0.12	-0.64	0.32	4.48	0.15	1.41			0.41	0.58
3252	0.41	4.26	0.89	10.69			0.12	1.42	0.03	0.32	0.24	2.63					0.41	0.69
3253	0.31	1.07	0.48	1.88			-0.43	-2.12	-0.04	-0.35	0.23	1.88	0.38	2.29			0.50	0.18
3254	-0.02	-0.73	0.09	1.18	-0.04	-1.6			0	0.05	0	0.16					-0.02	0.07
3255	0.02	1.04	0.4	4.61	0.04	2.41			-0.02	-0.78	0.16	2.95	0.28	2.51			0.03	0.51
3256	-0.02	-0.9	0.23	1.24	0.03	1.37			0.08	3.4	0.14	2.19					-0.02	0.25
326	0.11	2.87	1.02	10.99			0.05	1.43	-0.03	-0.78	0.24	2.84					0.11	0.72
3261	0.11	2.87	1.02	10.92			0.05	1.43	-0.03	-0.75	0.24	2.84					0.11	0.72
32611	0.23	2.79	0.68	6.59			0.06	0.87	-0.04	-0.47	0.17	2.29	0.2	2.08			0.29	0.61
32612	0.1	1.22	0.3	8.14			0.11	1.42	-0.05	-0.57	0.18	2.91	0.21	3.16	0.37	2.7	0.24	0.7
32613	0.1	3.1	0.11	1.56			0.05	1.65	-0.02	-0.57	0.11	1.56	0.27	2			0.14	0.29
32615	0	0.07	0.21	1.58	0.01	0.34			-0.16	-0.32	0.26	3.38	0.35	3.1			0.00	0.45
32616	-0.02	-0.52	0.57	9.54	-0.05	-1.3			0.01	0.22	0.08	1.42	0.21	2.68			-0.03	0.75
32619	0.06	1.52	0.84	5.62			0.04	1.26	-0.04	-1.09	0.22	2.38					0.06	0.43
32621	0.03	0.95	0.19	1.69	-0.02	-0.74			0.08	1.79	0.06	1.57	0.19	1.54	0.22	1.76	0.05	0.35
32629	0.13	2.97	0.29	1.07			-0.02	-0.48	0.06	1.18	0.35	3.89	0.05	0.49			0.14	0.34
327	0	0.17	0.71	5.9	0	0.13			0.04	1.16	0.14	1.85					0.00	0.42
3271	-0.06	-0.72	-0.12	-1.64			0.05	0.95	0.09	1.76	0.19	2.31					-0.06	0.17
3272	-0.06	-0.79	0.77	1.83	0.03	0.75			0.11	1.89	0.12	2.18	0.23	1.89			-0.08	0.22
3273	0.01	0.41	0.45	3.94			-0.06	-1.43	0.03	0.61	0.21	2.11					0.01	0.36
3274	-0.09	-1.53	0.25	2.78			0.03	0.56	0.05	0.95	0.15	1.81	0.21	1.55			-0.11	0.25
331	0.24	2.26	1.26	7.61	0.19	1.98			0.14	0.79	0.25	2.19	0.08	0.81			0.26	0.68

Table 3.1: Continued

Ind.	**C-ERPT**	**t**	**U.S. Cost**	**t**	**Cap. Util.**	**t**	**GDP**	**t**	**Wage**	**t**	**Deviation**	**t**	**P(-1)**	**t**	**P(-2)**	**t**	**S-ERPT**	R^2
3311	0.25	2.67	0.7	8.65	0.3	3.49			-0.14	-1.11	0.06	1.04	0.33	4.07			0.37	0.74
3312	0.17	3.41	0.63	7.2			0.01	0.29	0.02	0.39	0.33	4.29					0.17	0.86
3313	0.52	1.88	0.95	4.48	0.4	1.68			0	0.01	0.12	1.19					0.52	0.35
3314	-0.07	-0.29	0.61	3.61	0.23	1.07			-0.12	-0.5	0.17	2.2	0.42	3.78			-0.12	0.51
3315	0.45	10.84	0.95	5.53			0.07	1.62	0.04	0.75	0.15	1.47					0.45	0.73
332	0.08	2.8	1.42	7.82	0.02	0.81			0.03	0.66	0.18	3.64	0.23	2.8			0.10	0.75
3321	0.07	1.07	0.68	5.26	0.14	2.1			0.01	0.13	0.28	3.95	0.27	2.54			0.10	0.63
3322	0.1	2.33	0.09	2.56			-0.04	-1.54	0	-0.26	0.17	2.69	0.36	2.9			0.16	0.32
3323	0.26	2.84	0.22	2.84			-0.06	-1.05	0.07	0.74	0.14	2.62	0.91	6.78	-0.33	-2.18	0.62	0.62
3324	0.09	1.79	0.98	5.2			-0.02	-0.54	0.01	0.22	0.22	2.49					0.09	0.36
3325	0.16	6.08	0.17	1.12	0.01	0.36			0	-0.22	0.24	3.95					0.16	0.53
3326	0.13	4.33	0.52	7.34	0.03	1.24			0	0.09	0.09	2.04					0.13	0.57
3327	0.16	3.55	0.04	1.29			0	-0.26	0.02	0.77	0.24	4.76	0.54	4.66	0.25	2.02	0.76	0.59
3328	0.19	2.87	0.13	1.65			0	0.13	-0.08	-1.16	0.13	2.09	0.48	4.49			0.37	0.47
3329	0.32	4.04	0.18	2.59	0.09	2.1			-0.03	-0.65	0.13	1.82	0.46	4.27			0.59	0.48
333	0.15	8.96	0.269	2.62	0	0.1			0	0.08	0	0.06	0.35	4.3			0.23	0.68
33311	0.09	2.61	0.68	2.27			-0.03	-1.04	0.11	1.96	0.44	5.52	0.49	5.53			0.18	0.6
33312	0.35	8.32	0.28	1.36			-0.03	-0.8	0.05	0.79	0.15	2.15					0.35	0.6
33313	0.13	5.87	0.08	1.01			0	-0.25	0.07	1.97	0.1	1.7					0.13	0.45
3332	0.1	3.39	0.34	1.37	0	-0.26			0.03	0.8	0.09	1.49	0.23	2.01			0.13	0.35
3333	0.37	3.83	0.09	4.96			-0.02	-0.54	0	0.06	0.31	3.16					0.37	0.52
3334	0.06	3.13	0.2	2.12			-0.01	-0.91	-0.01	-1.18	0.09	1.82					0.06	0.27
3335	0.18	3.46	0.05	1.59			-0.03	-0.78	0.04	1.08	0.07	1.13	0.35	2.66			0.28	0.29
3336	0.32	2.37	0.24	1.53	0.01	0.74			0.07	1.59	0.2	2.35					0.32	0.76
334	0.43	14.19	0.02	4.59			-0.04	-1.61	0.02	0.44	0.14	2.1	0.13	2.19			0.49	0.85
3341	0.17	2.82	-0.14	-0.89			0.03	0.52	0.18	2.62	0.2	1.73					0.17	0.33
3342	0.54	8.19	0.03	1.16	0	0.19			0	0	0.35	2.49	0.12	1.23			0.61	0.64
3343	0.09	2.57	-0.05	-0.51	0.06	1.85			0.04	1.91	-0.06	-1.13	0.29	2.18			0.13	0.22
3344	0.66	11.93	1.06	11.93			-0.03	-0.67	0.04	0.77	0.18	2.08					0.66	0.81
3345	0.22	6.25	0.51	1.81			-0.03	-0.95	0	0	0.36	4.09					0.22	0.67

Table 3.1: Continued

Ind.	**C-ERPT**	**t**	**U.S. Cost**	**t**	**Cap. Util.**	**t**	**GDP**	**t**	**Wage**	**t**	**Deviation**	**t**	**P(-1)**	**t**	**P(-2)**	**t**	**S-ERPT**	R^2
3346	0.03	0.63	0.04	1.66	0.03	1.42			-0.01	-0.18	-0.15	2.47	0.36	2.79			0.05	0.23
3351	0.02	0.78	0.44	2.69			-0.05	-2.09	0.03	1.06	0.32	3.67					0.02	0.33
3352	0.01	0.49	0.45	3.35			-0.04	-1.66	-0.01	-0.52	0.22	4.17					0.01	0.31
3353	0.04	1.16	0.51	3.87			-0.04	-1.03	0	-0.1	0.11	1.71	0.14	1.15			0.05	0.37
336	0.77	6.78	0.2	3.41			-0.02	-0.74	0.01	0.26	0.09	1.44					0.77	0.93
3361	0.99	2.74	0.16	3.14			-0.04	-0.92	0	-0.09	0.11	1.54					0.99	0.9
3362	0.06	1.65	0	0.06			-0.05	-1.48	0	0.12	0.39	4.65	0.22	1.87			0.08	0.38
3363	0.37	13.29	0.28	1.51			-0.05	-1.92	-0.01	-0.54	0.22	2.6					0.37	0.8
3364	1.01	3.94	0.46	2.6			0	-0.02	-0.04	-1.19	0.41	3.51					1.01	0.96
3365	0.05	0.86	-0.03	-0.24	0.04	0.8			0.09	1.69	0.25	4.12	0.24	2.16			0.07	0.34
3366	0.56	10.75	0.08	0.3			0.09	1.73	0	0.15	0.1	2.13					0.56	0.69
3369	0.8	10.22	0.19	2.95			0.17	3.49	0	0.21	0.22	2.28	0.1	1.62			0.89	0.83
337	0.07	1.79	0.08	2.19	0	0.11			0.02	0.53	0.14	2.19	0.37	2.64			0.11	0.22
3371	0.12	1.84	0.09	1.54	0.03	1.04			-0.03	-0.84	0.19	2.85					0.12	0.18
3372	-0.02	-0.91	0.14	1.67			0.04	1.58	-0.01	-0.36	0.15	2.42	0.19	1.49	0.26	1.92	-0.04	0.34
3379	0.02	0.45	0.1	0.5			0.01	0.26	-0.01	-0.17	0.19	2.31					0.02	0.1
3399	0.20	1.85	0.12	1.39	-0.02	-0.95			0	0.04	0	0.02					0.20	0.08

Notes: C-ERPT denotes contemporaneous exchange rate pass-through, Cap. Util. shows capacity utilization in Canadian industries, Deviation is the speed of adjustment back to long-run equilibrium. P(-1) and P(-2) denote, respectively, first and second lags of dependent variable (Canadian producer price index), S-ERPT denotes short-run exchange rate pass-through. **t** indicates t-statistics.

For other industries, except for Motor vehicle [3361], Aerospace product and parts [3364] which their estimated pass-through coefficients are close to one, the contemporaneous pass-through estimates are positive and less than one which confirms the claim of partial pass-through in the literature. These results mean that when the Canadian dollar appreciates, the Canadian producer price decreases but less than proportionally. The average contemporaneous pass-through elasticity for the sample is 0.21 implying that, in general, the firms absorb a considerable part of exchange rate movements by varying their mark-up.[1] In fact, when domestic currency appreciates, domestic firms may be willing to sustain temporarily lower profits to maintain market shares, as long as profits are adequate. However, when domestic currency depreciates, domestic firms have this opportunity to increase their profit margins.

The estimated pass-through elasticity in this study is not very different from the values of 0.12 and 0.30 obtained by Kardasz and Stollery (2001, 2005) for 31 and 37 Canadian manufacturing industries respectively. At least three factors may explain the difference between these results: (1) the estimates in Kardasz and Stollery (2005)'s study are based on a longer time period (1963-1995 versus 1972-1989 in Kardasz and Stollery (2001) and 1992-2007 in the present study). Although the length of the time period in this study is similar to Kardasz and Stollery (2001)'s study, more free trade and therefore more pass-through is expected for the time period considered in this study because of NAFTA implementation; (2) different industries with different levels of aggregation have been used in these studies (3) the equations that were estimated and the econometric methods employed in these studies are quite different. Despite these differences, these studies are consistent with the following generalizations: (1) incomplete pass-through is observed in most industries, (2) pass-through into domestic producer prices varies substantially across industries. In this study, it changes from 0 to 1.01 for Aerospace product and parts [3364].

The histograms for the contemporaneous and the short-run pass-through elasticities in Figures 3.2 and 3.3 show the variations of pass-through across industries.[2] As Figure 3.2 indicates, the contemporaneous pass-through tends to be concentrated between zero and 0.40 in a way that about 90 percent of industries are in this range. Similar pattern is observed in Figure 3.3 for the short-run pass-through (after two quarters) where the pass-through for about 80 percent of industries is between zero and 0.40.

As Table 3.2 indicates, the estimated long-run exchange rate pass-through elasticities are

[1] The average short and long-run pass-through elasticities for the sample are 0.24 and 0.36 respectively.

[2] The vertical axis shows the number of industries and the horizontal axis indicates the extent of the ERPT.

Figure 3.2: Histogram for Contemporaneous Exchange Rate Pass-Through

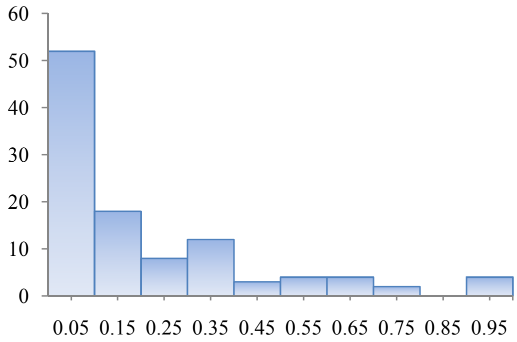
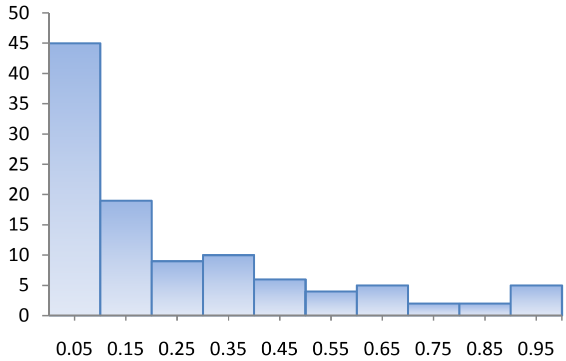


Figure 3.3: Histogram for Short-Run Exchange Rate Pass-Through



somewhat higher than the short-run elasticities, with an average of 0.36. The histogram in Figure 3.4 shows the variation of long-run pass-through elasticities across industries.

Figure 3.4: Histogram for Long-Run Exchange Rate Pass-Through

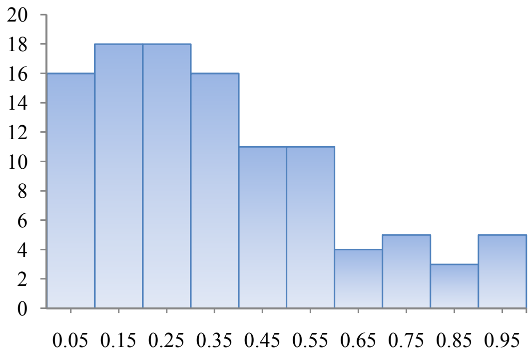


Table 3.2: Long-Run Exchange Rate Pass-Through

Ind.	**L-ERPT**	**t**	**US Cost**	**t**	**Cap. Util.**	**t**	**GDP**	**t**	**Wage**	**t**	R^2
311	0.33	7.42	0.79	4.71			-0.37	-0.88	0.07	0.54	0.91
3111	0.12	1.63	1.08	-7.63			-1.26	-3.66	-0.26	-1.25	0.89
3112	0.53	14.1	1.14	10.48			-0.18	-0.63	0.08	0.45	0.91
3113	0.25	9.26	1.16	6.45	0.6	3.06			0.08	0.76	0.76
3114	0.4	5.54	0.41	4.94			0.06	0.6	0.02	0.29	0.89
3115	0.18	9.21	0.01	0.27	-0.24	-1.99			0.01	0.26	0.93
3116	0.55	14.26	0.57	5.33			-0.3	-1.52	-0.15	-0.98	0.89
3118	0.15	4.7	-0.08	-0.59	-0.37	-2.45			0.17	2.47	0.79
3121	0.01	0.52	0.39	2.09			-0.06	-0.39	0.2	2.67	0.76
31213	0.15	2.38	0.65	4.14			-0.12	-0.51	0.19	1.59	0.82
31214	0.41	13.27	-0.15	-1.46			-0.07	-0.69	0.04	1.14	0.98
313	0.25	6.15	1.23	11.72			-0.25	-1.36	16	2.69	0.98
3131	0.24	4.51	1.18	5.72			-0.5	-3.7	0.4	3.46	0.98
3132	0.2	7.02	1.37	6.2			-0.5	-4.94	0.16	2.33	0.95
3133	0.1	4.4	0.2	1.85			0.04	0.49	0.01	0.4	0.97
3141	0.13	8.13	1.17	6.33			-0.13	-1.47	0.21	3.03	0.86
315	0.13	3.77	0.68	3.42	0.03	0.6			0.14	2.17	0.97
3151	0.18	8.75	0.12	1.32			-0.07	-0.95	0.18	4.61	0.97
3159	0.14	3.94	0.54	3.01			0.27	2.28	0.01	0.22	0.87
316	0.17	4.76	1.28	3.9	0.03	0.93			0	0.03	0.91
3162	0.17	4.86	1.52	7.66			0.02	0.21	-0.04	-0.68	0.94
3169	0.1	0.77	0	0.01			-0.06	-0.27	-0.24	-0.9	0.61
321	0.49	3.84	1.09	8.52	-0.2	-1.1			0.33	0.87	0.93
3211	0.69	3.86	1.53	7.7	-0.05	-2.02			-0.06	-0.12	0.91
3212	0.08	0.61	0.85	6.62	-0.05	-0.19			1.24	2.38	0.84
3219	0.41	12.09	0.43	6.77	0.15	2.32			-0.14	-1.3	0.88
322	0.47	9.07	1.33	2.58			-0.23	-1.1	0.17	1.02	0.97
32211	0.96	12.92	1.3	4.17	0.46	1.76			-0.96	-1.59	0.97
32212	0.74	12.46	1.65	10.69			0.34	1.47	0.02	0.14	0.97
32213	0.38	10.39	1.21	8.68	-0.01	-0.07			-0.02	-0.15	0.97

Table 3.2: Continued

Ind.	**L-ERPT**	**t**	**US Cost**	**t**	**Cap. Util.**	**t**	**GDP**	**t**	**Wage**	**t**	R^2
3222	0.21	2.4	0.52	5.16			-0.19	-0.72	0.13	0.7	0.85
32311	0.76	10.09	0.36	4.03			-0.18	-0.85	-0.58	-3.37	0.9
32312	0.23	8.29	-0.06	-0.4	0.16	2.96			0.01	0.23	0.91
324	0.74	11.19	0.91	2.03	0.07	0.54			-0.05	-0.33	0.99
32411	0.77	10.69	0.87	4.47	0.01	0.1			-0.02	-0.12	0.99
32412	0.36	3.7	0.45	2.29			-0.2	-0.55	-0.52	-2.9	0.94
32419	0.23	2.06	0.92	4.39	0	0.01			-0.72	-1.36	0.91
325	0.18	4.92	0.7	5.05	0.1	0.69			-0.33	-1.7	0.74
3251	-0.02	-0.36	0.24	1.82	0.33	1.06			0.06	0.18	0.89
3252	0.85	4.99	0.99	9.31			0.07	0.31	-0.48	-2.86	0.87
3253	1.17	6.54	1.22	6.5			-0.2	-0.49	-0.51	-0.75	0.83
3254	0.02	0.75	0.2	1.63	-0.08	-0.76			0	-0.1	0.91
3255	0.15	7.86	0.48	4.74	-0.01	-0.3			0.02	0.55	0.91
3256	0.16	3.58	0.12	1.66	0.02	0.36			0.1	2.66	0.95
326	0.27	11.11	1.13	11.98			0.09	0.89	0.15	1.95	0.92
3261	0.29	1.83	1.05	10.93			0	0.02	0.04	0.53	0.89
32611	0.54	5.46	0.99	6.12			0.06	0.19	-0.02	-0.1	0.62
32612	0.32	2.8	0.4	4.01			-0.11	-0.28	-0.39	-1.53	0.51
32613	0.09	2.57	0.84	9.88			0.19	1.49	0.28	3.38	0.92
32615	0.32	5.28	0.46	2.89	-0.06	-0.58			-0.01	-0.12	0.67
32616	0.05	1.01	0.69	4.27	-0.18	-1.73			0.32	2.2	0.67
32619	0.13	4.36	0.87	6.77			0.03	0.25	0.04	0.54	0.93
32621	0.17	1.83	0.38	1.7	-0.1	-0.79			0.38	2.76	0.82
32629	0.28	9.31	0.72	4.97			0.03	0.24	0.15	1.99	0.98
327	0.08	4.53	0.34	4.42	-0.02	-0.57			0.24	3.39	0.74
3271	0.43	5.74	0.25	3.38			0.05	0.33	0.47	5.03	0.93
3272	-0.03	-2.5	1.19	3.22	0.18	1.69			0.69	4.24	0.89
3273	0.06	2.84	0.17	3.26			0.08	0.87	0.18	2.87	0.69
3274	0.03	0.91	0.14	1.88			0.51	3.43	0.2	1.74	0.96
331	0.61	6.91	1.44	4.14	-0.2	-1.49			0.48	2.2	0.94

Table 3.2: Continued

Ind.	L-ERPT	t	US Cost	t	Cap. Util.	t	GDP	t	Wage	t	R^2
3311	0.9	7.35	1.33	8.56	0.42	2.3			-0.99	-1.16	0.77
3312	0.51	10.5	0.76	8.14			0.09	0.62	0.34	3.72	0.93
3313	0.58	8.87	1.27	2.61	0.37	1.57			-0.04	-0.22	0.88
3314	-0.22	-0.97	1.12	7.67	0.09	0.23			0.65	1.1	0.88
3315	0.53	7.55	1.03	4.2			0.33	3.08	0.19	2.22	0.97
332	0.33	6.09	1.59	7.23	0	0.05			0.16	1.49	0.86
3321	0.51	5.71	0.91	6.74	0.23	2.76			0.04	0.42	0.84
3322	0.5	6.61	0.28	8.87			-0.09	-0.89	0.07	1.82	0.94
3323	0.71	5.04	0.79	6.42			0	0	-0.57	-2.35	0.73
3324	0.28	8.85	1.15	9.13			-0.17	-1.36	0.19	2.08	0.82
3325	0.35	16.88	0.15	0.59	0.15	3.5			0.22	3.69	0.98
3326	0.44	7.08	1.03	5.99	-0.02	-0.32			0.02	0.27	0.84
3327	0.33	6.4	0.3	0.52			0.14	0.84	0.17	2.36	0.77
3328	0.69	9.73	0.48	6.53			0.38	1.49	0.29	1.69	0.85
3329	0.59	6.24	0.56	6.61	0	0.02			-0.19	-1.71	0.91
333	0.29	9.25	0.1	0.49	0.09	2.7			0.34	3.97	0.95
33311	0.37	7.26	1.44	5.83			0.09	0.88	0.16	2.32	0.96
33312	0.56	9.75	0.99	4.65			0.04	0.31	0.17	1.67	0.96
33313	0.23	8.38	0.06	0.48			-0.06	-0.86	0.45	6.54	0.97
3332	0.25	8.11	1.29	7.32	0	0			0.01	0.2	0.96
3333	0.39	8.44	0.01	0.44			0.01	0.12	0.13	1.63	0.91
3334	0.26	14.56	0.49	3.6			-0.06	-0.68	0.04	1.19	0.95
3335	0.45	9.66	0.15	3.56			0.05	0.31	0.35	4.74	0.91
3336	0.42	2.04	0.77	4.14	0.05	1.87			0.12	1.6	0.98
334	0.56	6.65	0.04	4.39			-0.35	-3.41	0.05	0.88	0.99
3341	0.05	1.31	0.1	1.01			-0.07	-0.32	0.48	5.31	0.98
3342	0.51	8.19	0.09	4.88	-0.1	-3.73			0.02	0.34	0.98
3343	0.16	3.12	0.61	1.89	0.08	3.82			0.1	1.47	0.98
3344	0.36	6.93	1.01	7.72			-0.42	-2.98	-0.02	-0.38	0.99
3345	0.33	12.27	0.78	2.34			-0.09	-1.07	0.39	6.66	0.98

Table 3.2: Continued

Ind.	**L-ERPT**	**t**	**US Cost**	**t**	**Cap. Util.**	**t**	**GDP**	**t**	**Wage**	**t**	R^2
3346	0.33	6.09	0.23	4.59	0.09	3.87			0.34	2.39	0.97
3351	0.2	13.01	0.26	2.96			-0.13	-1.85	0.13	3	0.97
3352	0.26	8.7	0.89	5.86			-0.33	-0.22	-0.11	-1.96	0.96
3353	0.27	6.37	1	8.74			-0.21	-1.58	-0.12	-1.73	0.84
336	0.85	3.65	0.29	2			-0.07	-0.68	0.1	0.94	0.99
3361	1.07	7.89	0.38	2.76			-0.06	-0.46	-0.05	-0.51	0.98
3362	0.03	8.31	0.19	2.91			0.04	0.42	0.13	1.88	0.87
3363	0.37	13.85	0.95	6.04			-0.25	-3.76	0.15	2.57	0.99
3364	1.07	5.46	0.55	2.9			-0.09	-1.33	-0.03	-1.08	0.99
3365	0.5	5.36	-0.01	-0.04	0.08	0.64			-0.19	-1.55	0.86
3366	0.63	12.94	0.18	0.28			0.58	2.35	0.15	1.11	0.91
3369	1.32	2.77	0.76	10.94			0.62	5.66	-0.09	-1.35	0.98
337	0.29	6.9	0.17	3.87	0.13	2.51			0.18	2.65	0.83
3371	0.35	5.57	0.13	2.01	0.25	3.57			0.05	0.76	0.85
3372	0.03	2.33	0.58	5.46			-0.04	-0.45	0.17	2.24	0.53
3379	0.23	5.28	0.67	2.55			0.32	2.19	0.11	1.5	0.93
3399	0.46	5.29	0.43	3.83	-0.23	-3.24			0.34	2.39	0.72

Notes: L-ERPT denotes the long-run exchange rate pass-through. Cap. Util. shows the capacity utilization in Canadian industries. t indicates t-statistics.

The elasticities for a number of industries, Iron and steel mills and ferroalloy manufacturing [3311], Pulp mills [32211], Pesticide, fertilizer and other agricultural chemical manufacturing [3253], Motor vehicle manufacturing [3361], Aerospace product and parts manufacturing [3364], Other transportation equipment manufacturing [3369], are about one, indicating that the pass-through is complete over time for these industries. Considering that the theoretical model predicts that the share of tradable inputs (intermediate materials) in production costs affects positively the exchange rate pass-through (specially in the long run because this process takes time), the relatively high share of tradable inputs in production costs (more than 62 percent relative to 54 percent as the average of the sample) is the likely cause of the high pass-through in these industries. The next section which identifies the determinants of exchange rate pass-through using a cross section regression can provide more accurate information regarding the extent that different factors have effect on the exchange rate pass-through.

Table 3.3 provides the average of the contemporaneous and long-run pass-through elasticities across major manufacturing industries (3-digit NAICS).

Table 3.3: Cross-Industry Variation in Exchange Rate Pass-Through

NAICS	N	C-ERPT	LR-ERPT
Food	7	0.14	0.31
Beverage	3	0.11	0.19
Textile mills	3	0.09	0.18
Textile product mills	1	0.00	0.13
Clothing	2	0.01	0.16
Leather	2	0.01	0.14
Wood	3	0.16	0.39
Paper	4	0.45	0.57
Printing	2	0.17	0.50
Petroleum	3	0.29	0.45
Chemical	6	0.35	0.39
Plastic	9	0.08	0.24
Non-metallic mineral	4	0.00	0.12
Primary metal	5	0.26	0.46
Fabricated metal	9	0.16	0.49
Machinery	8	0.20	0.37
Computer	6	0.28	0.29
Electrical equipment	2	0.02	0.24
Transportation equipment	7	0.54	0.71
Furniture	3	0.04	0.20
Miscellaneous	1	0.39	0.46

Notes: C-ERPT denotes the average of estimates of the contemporaneous exchange rate pass-through. LR-ERPT shows the average of estimates of the long-run exchange rate pass-through. N is the number of 4 and 5 digit NAICS industries included in the study.

As it can be observed, Transportation Equipment manufacturing [336] has relatively higher pass-through (about 0.54 contemporaneously and about 0.71 in long-run) than the other industries. On the other hand, Textile Product Mills manufacturing [314] and Non-metallic mineral product manufacturing [327] show very low pass-through (about zero percent contemporaneously and about 0.12 in long-run). The next section attempts to explain the variation of the ERPT across industries.

3.3.2 Determinants of Exchange Rate Pass-Through

In the second stage regression, equation 3.3 is estimated. However, as we know, if we want to use standard t-tests, we should accept this assumption that the dependent variable is normally distributed. Histograms in Figures 3.2 and 3.4 do not look like that for a normal distribution. If the distribution is not normal, the tests would be wrong. To solve this problem, as suggested by Yang (1997), the Weighted Least Square method is used with the inverse of the standard error of pass-through elasticity estimates as weights. The results of the second stage regression are reported in Tables 3.4 and 3.5 for the contemporaneous and the long-run pass-through elasticities respectively.

As can be seen from Table 3.4, IIT_k, as a measure for product differentiation, negatively affects the exchange rate pass-through elasticities. While the theoretical prediction regarding the sign of this variable is not clear, this negative coefficient shows that the positive relationship between the ERPT to the foreign firm's price and the degree of product differentiation is offset by the negative relationship between the reaction of the domestic producer price to changes in the foreign firm's price and the degree of product differentiation.[1] However, this coefficient is not statistically significant. The same pattern is also observed in the case of long-run pass-through elasticities in Table 3.5 except that the magnitude of the coefficient is smaller. In general, our estimation results show weak support of the theoretical prediction regarding the effect of the degree of product differentiation on the extent of exchange rate pass-through.

Table 3.4: Cross-Industry Estimates (Contemporaneous Exchange Rate Pass-Through)

Variable	Estimates	t-Statistic
Product Differentiation	-0.07	-0.90
Market Share of Foreign Firms	0.05	0.71
Share of Materials in Total Costs	0.38*	1.78
Capital to Labour Ratio	0.37**	5.22
Adjusted R-Squared	0.31	
Number of Observations	98	

Notes: * significant at the 10% level. ** significant at the 1% level.

In both contemporaneous and long run pass-through equations, the imports share SIM_k,

[1]Note that ERPT to the domestic producer price is equal to the ERPT to the foreign firm's price times the reaction of the domestic producer price to changes in the foreign firm's price.

measuring the American firms' market share in domestic market for industry k, does not have the expected sign and it is not statistically significant even at the 10% level. The share of intermediate materials, as the tradable inputs, in production costs $SMAT_k$ is used as a measure for the elasticity of the domestic marginal cost with respect to domestic price of intermediate materials. By assuming that the exchange rate pass-through to the domestic price of intermediate materials is equal to one, an increase in this elasticity means that changes in domestic production costs will increase as a result of a given amount of the appreciation or depreciation of the domestic currency and therefore, considering that the price is a mark-up on costs, the domestic price would be affected more by exchange rate changes, given other factors constant. As it can be observed, the estimated coefficients for this variable are positive (as it was expected) and statistically significant at 1% level in both contemporaneous and long-run pass-through equations. The magnitude of this coefficient in the long-run model is higher than the contemporaneous model (0.60 relative to 0.38).

Table 3.5: Cross-Industry Estimates (Long-Run Exchange Rate Pass-Through)

Variable	**Estimates**	**t-Statistic**
Product Differentiation	-0.06	-0.61
Market Share of Foreign Firms	0.08	1.07
Share of Materials in Total Costs	0.60**	2.27
Capital to Labour Ratio	0.25**	2.83
Adjusted R-Squared	0.40	
Number of Observations	98	

Note: ** significant at the 1% level.

The capital to labour ratio (KLR_k) variable is included in the model as a proxy for the elasticity of marginal cost with respect to output. Bils and Chang (2000) theoretically show, using a CES production function, and empirically confirm, based on the observations on 458 4-digit SIC manufacturing industries in U.S., that there is a negative relationship between the growth rate of capital to labour ratio and the growth rate of the marginal cost. Considering that the provided theoretical framework predicts that there is a negative relationship between the elasticity of marginal cost with respect to output and the pass-through, it is expected that the estimated coefficient for capital to labour ratio to be positive. As can be seen in Table 3.4, the parameter estimate for this variable is positive and statistically significant in both contemporaneous and long run pass-through equations (0.37 and 0.25, respectively).

As the estimated results in both tables show, the magnitude of the coefficient for $SMAT_k$ is relatively higher than the other parameter estimates and therefore is the most important factor which explains the variation of the exchange rate pass-through across industries. These results confirm our contribution to the theoretical model which shows the share of tradable inputs (intermediate materials) in production costs is one of the determinants of the exchange rate pass-through into domestic producer price. Moreover, the estimated coefficients for $SMAT_k$ and (KLR_k) validate our explanation in previous section that low or high exchange rate pass-through in some industries is most likely related to the level of these variables (the share of tradable inputs and the elasticity of marginal costs with respect to output) in different industries.

As the final point, although this study does not explicitly address this issue that whether the exchange rate pass-through in each industry may change over the time, the results of the second stage regression imply that the exchange rate pass-through in each industry can change over time as a result of over time changes in imports share, degree of product differentiation, the share of tradable inputs in total costs as well as the capital to labour ratio in each industry.

3.4 Summary and Conclusions

Exchange rate volatility between the US and Canadian dollars has dramatically increased in the past few years. Ongoing large U.S. trade and fiscal deficits, the slow down in the dollarization of trade, and the global financial crisis, coupled with impacts of increasingly volatile oil, metals, and grain prices on the Canadian dollar as a commodity currency, suggest that Canada/U.S exchange rate could continue to be volatile for the foreseeable future.

As statistics show, the United States is Canada's most important trading partner. In 2007, 76 percent of all Canadian exports were shipped to the U.S., and the U.S. supplied 65 percent of Canadian merchandise imports. Therefore, the Canada/U.S. exchange rate is a key economic factor that affects the prosperity of the Canadian economy in general, and the manufacturing sector specifically through changes in Canadian output and input prices. The significant appreciation/depreciation of the Canadian dollar in recent years has created great interest in the effects of these changes on Canadian economy. Examining the exchange rate pass-through (ERPT), which indicates the extent that Canadian output and input prices are affected by the exchange rate changes, can shed some light in this issue.

The exchange rate pass-through estimations help to identify and understand those markets which are more at risk from large variations in exchange rates which, in turn, can help in designing appropriate policies. Considering its importance, this study tried to model and estimate the extent of exchange rate pass-through (ERPT) and its determinants for industries in the Canadian manufacturing sector. To reach the goal, at first, a comprehensive review of theoretical and empirical models of exchange rate pass-through was provided. This literature review demonstrates the major factors that explain why exchange rate pass-through could be different from one (in contrast to the prediction of the law of one price) and different across sectors. Although each of these factors (or some of them) have been examined separately in different studies, there is not a general model that incorporate these factors together. Using a product differentiation model with an oligopolistic structure in provision of domestic products, this paper presents a relatively general model showing that exchange rate pass-through is higher in industries with higher share of tradable inputs in production costs, lower elasticity of marginal cost with respect to output, and lower market shares of foreign firms. The sign for the degree of substitutability among the variants is not theoretically clear and remains as an empirical question.

Using quarterly data for three, four, and (a few cases of) five digit NAICS industries (more than 100) in Canadian manufacturing sector for the years between 1992-2007, this study indicates that incomplete pass-through is observed in most cases although its magnitude is different across industries. The results show that the contemporaneous pass-through is less than 0.40 for more than 90 percent of industries. The average contemporaneous pass-through elasticity for the sample is 0.21 while the average short (after two quarters) and long-run pass-through elasticities are 0.24 and 0.36, respectively. These findings are not very different from the values of 0.12 and 0.30 obtained by Kardasz and Stollery (2001, 2005) for 31 and 37 Canadian manufacturing industries respectively. The results imply that, in general, firms absorb a considerable part of exchange rate movements by varying their mark-up. In fact, when domestic currency appreciates, domestic firms may be willing to sustain temporarily lower profits to maintain market shares, as long as profits are adequate. On the other hand, when domestic currency depreciates, domestic firms have this opportunity to increase their profit margins.

The second stage regressions show the effect of different factors on the magnitude of the contemporaneous and long run exchange rate pass-through elasticities. The product differentiation negatively affects the exchange rate pass-through elasticity which is consistent with the provided theoretical framework. However, this coefficient is not statistically significant. The estimation results show weak support of the theoretical prediction regarding the effect of the imports share on the extent of exchange rate pass-through. The estimated coefficient for this variable does not have the expected sign and is not statistically significant even at the 10% significance level.

The share of intermediate materials (tradable inputs) in production costs, as a measure for the elasticity of domestic marginal cost with respect to domestic price of intermediate materials, is statistically significant at 1% significance level in both contemporaneous and long run pass-through equations. The magnitude of this coefficient (0.38 and 0.60 in the contemporaneous and long run pass-through equations respectively) is considerably higher than the other parameter estimates and therefore is the most important factor which explains the variation of exchange rate pass-through across industries. This result confirms our contribution to the theoretical model which shows the share of tradable inputs (intermediate materials) in production costs is one of the determinants of the exchange rate pass-through into the domestic producer price. The capital to labour ratio (as an inverse measure of the elasticity of marginal cost with respect to output) coefficient indicates that one percent increase in the elasticity of marginal cost with respect to output will decrease the magnitude of the contemporaneous and long run exchange rate pass-through elasticities by 0.37 and 0.25 percent respectively.

Although this study does not explicitly address this issue that whether the exchange rate pass-through in each industry may change over the time, the results of the second stage regression imply that the exchange rate pass-through in each industry can change over time as a result of over time changes in imports share, degree of product differentiation, the share of tradable inputs in total costs as well as the capital to labour ratio in each industry. However, it seems that examining the variation of exchange rate pass-through during the time as well as examining whether price responses to exchange rate changes are symmetric can be interesting topics for future researches on exchange rate pass-through in Canadian manufacturing industries.[1]

The results of this analysis have several theoretical and policy implications. First, the results provide more support for this notion in the literature (Knetter, 1993; Yang, 1997) that industry differences in terms of market structures have implications for the degree of exchange rate pass-through in different industries. Second, as Yang (1997) also concludes, the theoretical predictions regarding to incomplete pass-through also apply to the effects of other shocks such as trade restrictions and changes in industrial policies.

[1]Symmetry means that the pass-through when exchange rate appreciates is equal to the pass-through when it depreciates.

Finally, the high rate of exchange rate pass-through for some industries, such as Paper mills and Transportation equipments, suggests that the producers in these industries need to be able to anticipate the risks associated with exchange rate changes and develop risk management strategies. Some strategies like hedging, marketing and procurement strategies would mitigate the financial risk associated with exchange rate volatility. The public sector may play a role in the development and extension of these tools for producers.

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APPENDICES

Appendix D

Tests Results for Unit Root and the Estimation Results for First Difference Model

Table D.1: ADF Test Statistics and Critical Values for Data and Residuals

Industry	Cdn Price	U.S. Cost	Cdn Wage	Cdn Cap. Util.	Residual	10%	5%	1%	P-value
311	-1.81	-1.62	-2.83		-3.89	-4.23	-4.48	-5.02	0.211
3111	-2.34	0.42	-2.82		-3.55	-4.06	-4.33	-4.92	0.363
3112	-2.54	1.04	-3.32		-3.62	-4.09	-4.38	-4.95	0.297
3113	-2.63	-1.92	-3.07		-4.4	-4.22	-4.48	-4.95	0.060
3114	-2.01	-2.65	-2.74		-4.75	-5.08	-5.37	-5.90	0.199
3115	-1.03	-3.1	-2.1		-4.5	-4.88	-5.22	-5.84	0.210
3116	-0.26	-2.5	-2.82		-4.36	-4.45	-4.76	-5.59	0.124
3118	-2.45	-2.07	-1.24		-3.07	-4.23	-4.44	-5.23	0.538
3121	-0.83	-2.07	-1.55		-3.10	-4.06	-4.37	-4.96	0.619
31213	-2.18	-1.71	-1.55		-3.78	-4.37	-4.68	-5.24	0.326
31214	-0.89	-1.99	-1.55		-3.65	-4.66	-4.98	-5.77	0.537
313	-1.16	-1.2	-3.19		-3.65	-4.11	-4.30	-5.08	0.253
3131	-2.4	-1.09	-1.97		-4.21	-4.36	-4.65	-5.01	0.142
3132	-0.85	-1.46	-1.9		-3.84	-4.63	-4.90	-5.51	0.426
3133	-2.1	-1.47	-2.62		-5.1	-4.79	-5.07	-5.67	0.048
3141	-1.22	-3.3	-2.18		-5.06	-4.50	-4.71	-5.24	0.018
315	-0.78	-0.52	-3.96	-1.45	-3.73	-4.53	-4.84	-5.34	0.406
3151	-0.93	-1.68	-3.28		-4.95	-4.94	-5.22	-5.85	0.098
3159	-1.19	-1.03	-3.96		-3.81	-4.00	-4.24	-4.75	0.172
316	-0.65	-1.75	-3.89	-2.55	-4.02	-4.05	-4.30	-4.77	0.110
3162	-0.37	-1.76	-4.1		-4.59	-4.06	-4.32	-4.80	0.027
3169	-1.44	-1.03	-2.04		-3.66	-4.20	-4.44	-5.06	0.349
321	-3.12	-3.19	-0.39	-2.38	-4.55	-4.78	-5.01	-5.55	0.163
3211	-3.86	-3.07	-0.48	-2.38	-3.64	-4.24	-4.54	-5.10	0.301
3212	-2.8	-1.82	-2.18	-2.38	-4.20	-4.35	-4.64	-5.24	0.137
3219	-2.91	-2.03	-1.04	-2.38	-4.08	-4.57	-4.81	-5.42	0.273
322	-2.12	-1.76	-2.42		-4.51	-4.53	-4.76	-5.40	0.106
32211	-2.13	-3.01	-2.42	-2.81	-5.41	-4.51	-4.75	-5.21	0.005
32212	-2.14	-3.16	-2.42		-3.76	-4.31	-4.57	-5.06	0.340
32213	-2.15	-3.45	-2.42	-2.81	-3.7	-4.12	-4.41	-5.03	0.275
3222	-2.16	-3.09	-1.47		-3.69	-4.53	-4.76	-5.41	0.516
32311	-1.89	-0.05	-3.38		-3.98	-4.17	-4.43	-4.96	0.161
32312	-1.18	-1.2	-3.38	-2.16	-4.04	-4.31	-4.54	-5.10	0.194
324	-2.53	-1.75	-2.98	-2.22	-3.55	-4.09	-4.35	-4.94	0.310
32411	-2.56	-1.82	-2.98	-2.22	-3.42	-4.03	-4.28	-4.85	0.379
32412	-2.3	-1.45	-2.98		-3.50	-4.21	-4.53	-5.06	0.364
32419	-1.56	-0.39	-2.98	-2.22	-3.72	-4.30	-4.60	-5.26	0.310
325	-3.03	-1.88	-2.51	-1.96	-3.92	-4.20	-4.46	-5.04	0.228
3251	-3.11	-2.49	-2.61	-1.96	-3.85	-4.50	-4.77	-5.46	0.366
3252	-3.11	-2.01	-1.1		-5.24	-4.62	-4.87	-5.51	0.017
3253	-1.94	0.98	-3.13		-3.97	-4.51	-4.83	-5.72	0.332
3254	-3.07	-2.49	-2.24	-1.96	-3.2	-3.73	-3.99	-4.55	0.329
3255	-2.24	-0.73	-2.24	-1.96	-4.24	-4.88	-5.17	-6.02	0.317
3256	-1.58	-0.68	-2.63	-2.82	-3.63	-4.13	-4.33	-4.67	0.244
326	-2.26	-1.01	-1.96		-4.98	-5.08	-5.36	-5.91	0.129

Table D.1: Continued

Industry	Cdn Price	U.S. Cost	Cdn Wage	Cdn Cap. Util.	Residual	10%	5%	1%	P-value
3261	-2.64	-1.57	-1.84		-4.81	-5.12	-5.40	-5.88	0.193
32611	-2.46	-1.84	-1.84		-3.35	-3.85	-4.16	-4.59	0.302
32612	-3.07	-2.43	-1.87		-4.62	-4.67	-4.91	-5.40	0.110
32613	-0.84	-2.63	-1.87		-4.48	-4.54	-4.83	-5.52	0.123
32615	-1.87	-0.87	-1.87	-2.22	-4.09	-4.09	-4.27	-4.58	0.100
32616	-3.12	-2.23	-1.87	-2.22	-3.19	-3.79	-3.99	-4.46	0.385
32619	-2.87	-2.13	-1.87		-4.92	-4.62	-4.81	-5.38	0.036
32621	-2.45	0.88	-2.93	-2.22	-2.04	-3.71	-3.91	-4.36	0.947
32629	-0.72	-1.62	-2.93		-4.16	-4.38	-4.69	-5.24	0.161
327	-0.98	-0.8	-2.29	-1.88	-4.26	-4.41	-4.70	-5.42	0.140
3271	-2.17	-1.23	-2.16		-3.54	-4.50	-4.82	-5.37	0.576
3272	-2.06	-1.62	-3.54	-1.79	-3.52	-4.03	-4.35	-5.09	0.297
3273	-2.57	-2.36	-2.92		-4.97	-4.49	-4.70	-5.15	0.021
3274	-3.31	-3.32	-3.15		-4.5	-4.38	-4.72	-5.42	0.083
331	-1.17	-0.92	-2.11	-2	-4.23	-4.51	-4.75	-5.37	0.183
3311	-3	-1.6	-2.22	-3.18	-3.15	-3.90	-4.15	-4.47	0.490
3312	-2.87	-1.2	-1.85		-4.55	-4.18	-4.42	-4.91	0.035
3313	-2.84	-2.35	-2.06	-2	-3.98	-4.21	-4.48	-5.06	0.193
3314	0.46	-0.61	-2.71	-2	-3.81	-4.47	-4.81	-5.62	0.350
3315	-1.91	0.19	-2.83		-4.09	-4.06	-4.31	-4.92	0.092
332	-2.75	-0.79	-1.85	-1.88	-3.51	-4.19	-4.49	-5.09	0.469
3321	-3.11	-1.4	-2.4	-1.78	-4.04	-4.34	-4.62	-5.10	0.223
3322	-1.84	-1.29	-1.32		-4.09	-4.80	-5.15	-5.98	0.46
3323	-1.52	-1.58	-1.93		-3.36	-3.83	-3.98	-4.59	0.300
3324	-1.7	-1.45	-3.07		-3.46	-3.73	-3.96	-4.35	0.179
3325	-1.34	-1.53	-2.36	-1.78	-4.94	-4.87	-5.16	-5.76	0.084
3326	-1.72	-1.24	-1.55	-1.78	-3.40	-3.78	-4.06	-4.51	0.242
3327	-2.31	0.18	-2.03		-4.13	-4.67	-4.90	-5.54	0.262
3328	-2.11	-2.12	-3.88		-4.45	-4.14	-4.38	-4.98	0.044
3329	-1.88	-0.56	-1.79	-1.78	-4.54	-4.53	-4.81	-5.54	0.098
333	-0.83	0.29	-2.05	-2.26	-3.43	-4.19	-4.44	-5.02	0.445
33311	0.54	-2.13	-2.75		-3.93	-4.34	-4.65	-5.14	0.201
33312	-0.57	-1.33	-2.75		-3.57	-3.97	-4.31	-4.86	0.258
33313	-1.15	0.52	-2.75		-4.45	-4.71	-4.99	-5.49	0.180
3332	-0.35	-1.83	-1.82	-2.26	-4.23	-4.43	-4.75	-5.32	0.143
3333	-2.36	-1.45	-2.21		-4.58	-4.38	-4.58	-5.20	0.050
3334	-0.96	-0.06	-2.79		-4.02	-4.65	-4.96	-5.44	0.298
3335	-2.14	-3.16	-2.24		-3.57	-3.95	-4.28	-4.85	0.212
3336	-0.62	-1.5	-2.18	-2.26	-3.28	-4.13	-4.39	-4.88	0.432
334	0.2	-1.32	-2.29		-3.96	-4.48	-4.75	-5.19	0.269
3341	-3.07	-2.31	-3.16		-3.72	-4.19	-4.49	-5.01	0.233
3342	-1.81	-2.41	-1.83	-2.82	-5.52	-4.63	-4.92	-5.77	0.015
3343	-2.06	0.77	-3.05	-2.94	-3.52	-4.38	-4.61	-5.19	0.442
3344	-1.54	-0.33	-1.65		-4.32	-4.41	-4.73	-5.34	0.125
3345	0.14	-2.35	-2.45		-3.96	-4.56	-4.84	-5.51	0.293
3346	-2.74	-2.6	-2.45	-2.94	-4.09	-4.64	-4.94	-5.62	0.254
3351	-0.81	-1.97	-3.2		-4.9	-4.94	-5.22	-5.89	0.121

Table D.1: Continued

Industry	Cdn Price	U.S. Cost	Cdn Wage	Cdn Cap. Util.	Residual	10%	5%	1%	P-value
3352	-1.15	-1.88	-2.25		-4.27	-4.54	-4.93	-5.45	0.168
3353	-2.83	0.65	-2.15		-4.03	-4.46	-4.67	-5.52	0.268
336	-0.71	-3.31	-2.08		-2.16	-3.87	-4.11	-4.59	0.960
3361	-0.53	-2.48	-2.16		-2.74	-3.63	-3.87	-4.43	0.563
3362	-1.79	-1.22	-2.16		-4.97	-4.56	-4.99	-5.65	0.053
3363	-0.72	-1.79	-1.42		-3.92	-4.45	-4.76	-5.34	0.293
3364	-0.87	-1.15	-3.12		-3.82	-4.23	-4.45	-5.14	0.204
3365	-0.39	-0.66	-3.16	-1.76	-3.6	-4.16	-4.43	-5.16	0.322
3366	-0.81	-1.66	-3.23		-3.49	-3.80	-4.01	-4.61	0.198
3369	-1.24	-0.29	-1.19		-4.44	-4.34	-4.69	-5.31	0.083
337	-1.43	-2.2	-2.64	-2.32	-3.75	-4.33	-4.63	-5.11	0.341
3371	-1.54	-2.4	-2.5	-2.32	-3.58	-3.96	-4.21	-4.65	0.236
3372	-2.82	-1.94	-2.61		-5.87	-4.63	-4.85	-5.41	0.002
3379	-1.93	-2.23	-2.19		-3.88	-4.17	-4.49	-5.04	0.203
3399	-1.44	-1.15	-1.7	-2.56	-2.31	-3.86	-4.07	-4.40	0.980

Notes: All individual variables have been considered in logarithm form.

ADF test statistics for GDP and Exchange Rate (in logarithm form) are -3.14 and -0.04, respectively.

Columns 2-5 show the ADF test statistics for Canadian price, U.S. cost, Canadian wage and capacity utilization.

Column 6 shows the ADF test statistics for the Residuals obtained from the long-run relationships.

Columns 7-9 show the bootstraped critical values to reject unit roots in residuals at 10, 5 and 1 percent levels.

Critical values to reject unit roots in individual series at 10, 5 and 1 percent levels are -3.17, -3.48, and -4.12.

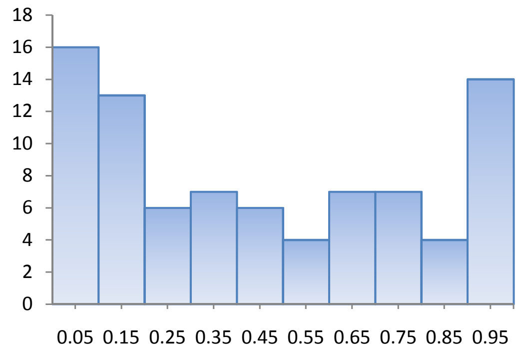
The Estimation Results for First Difference Model

Estimation results of the first difference model are reported in Table D.2.[1] Among the explanatory variables, except for the exchange rate as the variable we are specially interested in, the U.S. cost is the most important variable which affects the Canadian producer prices with the average of 0.48. For 72 percent of industries, this variable is statistically significant. Figure D.1 represents the histogram of the estimated coefficients for this variable across industries. Although this coefficient for the 50 percent of industries is less than 0.40, it is close to one for 17 percent of industries.

The capacity utilization and GDP in Canada, which are the measures for demand pressure, are much less important. The estimated coefficients of capacity utilization are statistically significant for only seven of the 31 industries and only for 15 of the 53 industries in the case of the GDP estimates. The estimated coefficients for capacity utilization and GDP are less than 0.10 in more than 21 and 26 industries respectively. The largest estimated coefficients for capacity utilization is 0.39 which belongs to Alumina and aluminum production and processing [3313] while the largest estimated coefficients for GDP is 1.66 which belongs to

[1] This model is related to the case that we do not accept that there is a long run relationship (cointegration) between explanatory variables.

Figure D.1: Histogram of the Estimated Coefficients for the U.S. Cost



Other petroleum and coal products manufacturing [32419]. The wage in Canada is the least important variable. This variable is statistically significant for only two industries among the all considered industries. The estimated coefficient for this variable is more than 0.10 in just four industries. The largest estimated coefficient is 0.38 which belongs to Veneer, plywood and engineered wood product manufacturing [3212] .

The contemporaneous and short-run (after two quarters) estimations of exchange rate pass-through elasticities are presented in the second and sixteenth columns of Table D.2 respectively. Although three of the industries have negative estimates for the contemporaneous pass-through elasticities, Other petroleum and coal products [32419], Lime and gypsum product [3274], and Plastic bottle [32616], none of them is statistically different from zero even at the 10 percent significance level. Two industries show zero estimates for the contemporaneous pass-through elasticities: Glass and glass product [3272], and Polystyrene [32615].

For other industries, except for Motor vehicle [3361], Aerospace product and parts [3364] which their estimated pass-through coefficients are close to one, the contemporaneous pass-through estimates are positive and less than one which confirms the claim of partial pass-through in the literature. These results mean that when the Canadian dollar appreciates, the Canadian producer price decreases but less than proportionally. The average contemporaneous and short run pass-through elasticities for the sample are 0.24 and 0.27 respectively implying that, in general, the firms absorb a considerable part of exchange rate movements by varying their mark-up.

Table D.2: The Exchange Rate Pass-Through in the First Difference Model

Ind.	C-ERPT	t	U.S. Cost	t	Cap.Util.	t	GDP	t	Wage	t	P(-1)	t	P(-2)	t	S-ERPT	R^2
311	0.14	3.43	0.48	5.37			-0.07	-0.33	0.01	0.24					0.14	0.47
3111	0.09	0.87	1	7.18			-1.05	-1.86	-0.02	-0.18					0.09	0.58
3112	0.42	4.61	0.67	6.59			-0.14	-0.28	0.01	0.09					0.42	0.58
3113	0.2	3.08	0.53	2.61	0.13	0.97			0.03	0.45	0.12	1.07			0.23	0.23
3116	0.27	2.63	0.61	6.88			0	0	0.02	0.16	0	0.06	-0.21	-2.26	0.22	0.53
31214	0.34	10.38	0.07	0.7			-0.04	-0.24	-0.01	-0.34	-0.04	-0.59			0.33	0.68
313	0.09	4.37	0.5	3.76			0.01	0.15	0.02	1.27	0.22	2.04			0.12	0.44
3131	0.14	2.95	0.7	4.8			-0.07	-0.26	0.04	1.35	0.28	2.61			0.19	0.49
3132	0.06	2.84	0.35	2.31			-0.17	-1.35	0.01	0.79					0.06	0.22
315	0.01	1.04	0.36	2.6	0	-0.89			0	-0.61	0.41	3.55			0.02	0.29
3159	0	0.33	0.5	2.6			0.36	2.63	0.01	0.96	0.18	1.74			0.00	0.26
316	0.05	1.92	0.06	0.41	0	-0.89			0.02	0.98	0.35	2.75			0.08	0.18
3162	0.03	1.06	0.14	0.55			-0.14	-0.77	-0.02	-0.88	0.15	1.15	0.26	2.11	0.05	0.19
3169	0.05	1.04	0	-0.2			0.18	0.71	-0.01	-0.22					0.05	0.04
321	0.46	2.86	1.42	2.11			0	0	0.21	0.69	-0.28	-3.99			0.36	0.74
3211	0.49	2.31	1.54	11.29	0.11	0.56			-0.04	-0.13	-0.22	-3.02			0.40	0.73
3212	0.07	0.3	0.88	8.47	0.37	1.51			0.38	0.99	-0.17	-1.84			0.06	0.59
3219	0.15	3.05	0.31	4.69	0.01	0.27			0.08	1.32	0.19	1.78			0.19	0.42
322	0.49	5.18	1.06	9.14			0.85	1.6	0.12	0.85	0.11	1.35			0.55	0.81
32211	0.75	3.93	1.14	5.61	0.34	1.66			0.02	0.09					0.75	0.83
32212	0.61	8.01	1.02	11.12			0.54	1.21	-0.09	-0.83	0.25	3.96			0.81	0.87
32213	0.28	3.78	0.96	6.02	0.02	0.35			0.02	0.24	0.13	2.5			0.32	0.91
3222	0.03	0.51	0.01	0.47			0.73	2.03	-0.04	-0.43	0.64	6.28			0.08	0.45
32311	0.26	3.37	0.1	1.62			0.4	1.79	0.07	1.06	0.69	7.42			0.84	0.6
324	0.53	4	0.73	2.33	-0.04	-0.37			-0.18	-1.07	0.07	1.7	0.02	0.67	0.58	0.91
32411	0.54	3.69	0.71	2.95	-0.02	-0.23			-0.09	-0.53	0.07	1.53			0.58	0.9
32412	0.23	1.35	1.24	4.25			0.27	1.53	-0.42	-1.92	0.11	1.12	-0.51	-3.86	0.16	0.51
32419	-0.15	-1.16	0.69	3.34			1.66	2.45	-0.12	-0.81					-0.15	0.26
325	0.2	2.95	1.21	7.61	0.03	0.55			-0.04	-0.39					0.20	0.55
3251	0.31	2	0.8	5.47	0.12	0.84			0.05	0.22					0.31	0.41

Table D.2: Continued

Ind.	C-ERPT	t	U.S. Cost	t	Cap.Util.	t	GDP	t	Wage	t	P(-1)	t	P(-2)	t	S-ERPT	R^2
3252	0.34	3.6	0.8	9.94			1.25	2.51	0.06	0.5					0.34	0.67
3253	0.19	0.64	0.24	1.07			-0.41	-1.96	0.02	0.17	0.24	1.59			0.25	0.12
3255	0.02	1.16	0.32	3.66	0.04	2.27			-0.03	-1.4	0.32	2.69			0.03	0.44
326	0.07	2.57	0.82	8.14			0.38	2.54	0	0.1	0.16	1.81			0.08	0.69
3261	0.09	2.49	0.93	10.46			0.46	2.31	-0.04	-1.05					0.09	0.7
32611	0.16	2	0.66	6.2			0.52	1.21	-0.03	-0.35	0.18	1.77			0.20	0.56
32612	0.06	0.72	0.29	7.24			0.63	1.32	-0.05	-0.52	0.29	3.21			0.08	0.61
32613	0.1	2.92	0.04	0.66			-0.01	-0.09	-0.03	-0.92	0.3	2.09			0.14	0.22
32614,5	0	-0.14	0.35	2.56	0.03	0.71			-0.18	-0.29	0.28	2.33			0.00	0.33
32616	-0.01	-0.23	0.57	9.47	-0.04	-1.04			-0.01	-0.23	0.2	2.53			-0.01	0.74
32619	0.05	1.48	0.76	5.47			0.4	2.07	-0.05	-1.19					0.05	0.4
32621	0.03	0.83	0.25	2.42	-0.01	-0.62			0.06	1.36	0.2	1.58	0.2	1.59	0.05	0.32
32629	0.13	2.8	0.45	1.54			0.17	0.65	0.03	0.65					0.13	0.17
327	0.01	0.55	0.73	6.01	0	0.16			0.02	0.61					0.01	0.39
3273	0.02	0.57	0.48	3.89			0.29	1.2	0	0.17					0.02	0.25
3274	-0.12	-1.17	0.19	2.55			0.93	3.17	0.03	0.84					-0.12	0.31
331	0.26	2.4	1.12	10.27	0.2	2.06			0.08	0.46					0.26	0.65
3311	0.26	2.83	0.68	8.6	0.31	3.6			-0.1	-0.82	0.35	4.45			0.40	0.73
3312	0.13	2.69	0.57	12.8			0.71	2.66	0.04	0.64					0.13	0.86
3313	0.41	1.56	1.05	4.82	0.39	1.63			0	0	-0.25	-1.75			0.33	0.37
3314	0.08	0.31	0.66	3.77	0.24	1.11			-0.21	-0.86	0.36	3.19			0.13	0.47
3315	0.45	12.39	0.83	7.37			0.74	3.71	0.06	1.33					0.45	0.77
332	0.12	3.76	0.98	6.51	0.04	1.36			-0.01	-0.24	0.27	3.01			0.16	0.69
3321	0.09	1.27	0.9	3.17	0.21	2.85			0.05	0.7	0.49	3.63	-0.21	-1.82	0.13	0.55
3323	0.26	2.69	0.2	2.47			0.14	0.41	0.04	0.42	o.91	6.71	-0.43	-2.88	0.62	0.55
3324	0.12	2.3	0.72	4.4			0.06	0.22	0	0.02					0.12	0.29
3325	0.18	6.02	-0.08	-0.5	-0.01	-0.37			-0.05	-1.29					0.18	0.4
3326	0.12	4.34	0.38	5.03			0.06	0.42	0.01	0.45	0.27	2.7			0.16	0.59
3327	0.12	2.34	0.04	0.97			0.05	0.29	0	-0.08	0.58	4.98			0.29	0.39
3328	0.22	3.54	0.13	1.66			0.81	2.25	-0.07	-0.97	0.41	3.92			0.37	0.48

Table D.2: Continued

Ind.	**C-ERPT**	**t**	**U.S. Cost**	**t**	**Cap.Util.**	**t**	**GDP**	**t**	**Wage**	**t**	**P(-1)**	**t**	**P(-2)**	**t**	**S-ERPT**	R^2
3329	0.34	4.1	0.17	2.32	0.11	2.44			-0.03	-0.64	0.42	3.9			0.59	0.44
333	0.15	9.07	0.25	2.65	0	0.11			0	0.12	0.35	4.44			0.23	0.68
33311	0.13	3.09	0.17	0.48			0.24	0.96	-0.03	-0.5	0.39	3.44			0.21	0.33
33312	0.34	8.48	0.2	1.07			0.22	0.96	0.03	0.49					0.34	0.58
33313	0.13	6.12	0.11	1.5			0.15	1.26	0.03	0.92					0.13	0.45
3332	0.1	3.44	0.21	0.91	0	-0.25			0.03	0.73	0.23	1.95			0.13	0.32
3333	0.41	5.11	0.1	1.77			0.23	0.83	-0.03	-0.5					0.41	0.42
3334	0.06	3.44	0.18	1.89			-0.11	-1.02	-0.02	-1.63					0.06	0.23
3335	0.18	3.32	0.05	1.36			-0.19	-0.79	0.02	0.61	0.3	2.39			0.26	0.27
3336	0.32	11.8	0.29	1.72	0	0.5			0.02	0.61					0.32	0.74
334	0.48	5.44	0.02	3.93			-0.09	-0.54	0.04	0.96	0.14	2.31			0.56	0.83
3341	0.25	4.17	-0.08	-0.5			-0.33	-0.99	0.13	1.89					0.25	0.34
3342	0.56	8.51	0.01	0.54	0	0.28			0.04	0.52					0.56	0.59
3343	0.09	2.59	-0.14	-1.16	-0.12	-0.66			0.04	1.63	0.2	1.61			0.11	0.16
3344	0.69	13.25	0.98	6.2			0.17	0.63	0.05	0.9					0.69	0.82
3345	0.3	8.79	0.53	1.81			0	0.02	-0.04	-1.19					0.30	0.58
3353	0.08	1.69	0.46	2.48			0.08	0.32	-0.04	-0.73	0.64	5.13	-0.44	-3.49	0.10	0.41
336	0.76	7.6	0.22	3.74			-0.07	-0.46	0.01	0.22					0.76	0.93
3361	0.97	2.59	0.16	3.21			-0.13	-0.57	0	0.16					0.97	0.9
3363	0.39	14.03	0.18	0.94			-0.03	-0.19	-0.02	-0.65					0.39	0.78
3364	0.99	3.73	0.36	2.04			0	0.01	-0.05	-1.26					0.99	0.94
3366	0.52	10.79	0.02	0.12			0.5	1.88	0.02	0.57					0.52	0.7
3369	0.65	9.85	0.05	1.03			0.44	1.76	0	0.05	0.04	0.68			0.68	0.79
3399	0.2	1.85	0.12	1.39	-0.02	-0.95			0	0.04					0.20	0.08

Notes: C-ERPT denotes contemporaneous exchange rate pass-through, Cap.Util. shows capacity utilization in Canadian industries. P(-1) and P(-2) denote respectively, first and second lags of dependent variable (Canadian producer price index), SR-ERPT denotes short-run exchange rate pass-through. **t** indicates t-statistics. Compare to the ECM, 22 industries were removed from the analysis because of the low performance of their equations (low or even negative R-square and insignificancy of the variables). This might be considered as an evidence that the ECM model (accepting that the variables are cointegrated in the long run) is more appropriate.

The histograms for the contemporaneous and short-run pass-through elasticities in Figures D.2 and D.3 show the variations of pass-through across industries. As Figure D.2 indicates, the contemporaneous pass-through tends to be concentrated between 0 and 0.40 in a way that 77 percent of industries are in this range. Similar pattern is observed in Figure D.3 for the short-run pass-through (after two quarters).

Figure D.2: Histogram for Contemporaneous Exchange Rate Pass-Through

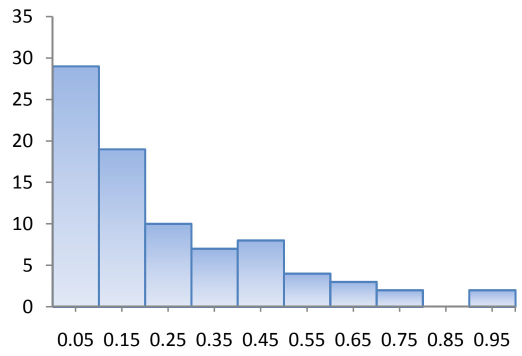
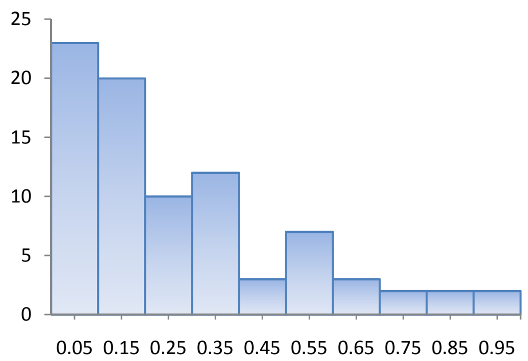


Figure D.3: Histogram for Short-Run Exchange Rate Pass-Through



Appendix E

Data Sources and the Name of Industries

Canadian Producer Price Index: Table 329-0038 Industry price indexes, by North American Industry Classification System (NAICS), monthly (index, 1997=100), Seasonally adjusted.

Capacity Utilization: Table 028-0002 Industrial capacity utilization rates, by North American Industry Classification System (NAICS 3 digit), quarterly (percent), Seasonally adjusted. Since these data are not available at 4 and 5 digits, I used 3 digit data as the proxy in all related 4 and 5 digits sub-sectors.

Wage: Table 281-0026 Average weekly earnings (SEPH), unadjusted for seasonal variation, by type of employee for selected industries classified using the North American Industry Classification System (NAICS), computed quarterly average (dollars). To use this variable in estimation of the equations, I made it seasonally adjusted by X11 method.

Gross Domestic Product (GDP): Table 379-0027 Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS), computed quarterly figures (dollars x 1,000,000) (2002 constant prices), Seasonally adjusted.

Exchange rate: Table 176-0049 Foreign exchange rates, United States and United Kingdom, computed quarterly average of spot rate (cents).

Intra-industry trade index (IIT): This index has been calculated for each industry using the annual imports and export values from and to U.S. reported in the web-site of industry Canada (www.ic.gc.ca) for the time period between 1992-2007. Then, a simple average of the calculated indexes has been used in the model.

Imports share (SIM): For each industry, this variable is defined as: (imports from U.S.)/(total shipments by Canadian firms - exports to U.S.+ imports from U.S.). The source of the data for this variable is same as IIT. The variable used in the model is a simple average of the calculated imports shares for the time period between 1992-2007.

Intermediate materials cost share (SMAT): This variable, as a measure for the share of tradable inputs in total costs, has been calculated for each industry using the annual values of intermediate materials costs and total expenses reported in the Tables 301-0003 and 301-0006 of CANSIM (Principal statistics for manufacturing industries, by North American Industry Classification System (NAICS)) for the time period between 1992-2007. A simple average of the calculated shares has been used in the model.

Capital to labour ratio (KLR): This variable is constructed as total end-year gross stock in million dollar divided by total employees. Data for end-year gross stock are from Table 031-0002 of CANSIM (Flows and stocks of fixed non-residential capital, by North American Industry Classification System (NAICS), annual) and data for the number of employees are from Tables 031-0003 and 031-0006 of CANSIM. This ratio has been calculated for each industry in the time period between 1992-2007 and then the simple average of the calculated shares has been used in the model.

Labour Productivity (as a measure for productivity) in Canadian Economy: Table 383-0012 Indexes of labour productivity and related variables, by North American Industry Classification System (NAICS), seasonally adjusted, quarterly (index, 2002=100).

Implicit Price Deflator in Canada: Table 383-0008 Indexes of labour productivity, unit labour cost and related variables, seasonally adjusted, quarterly (index, 2002=100).

Total unit cost index (TUCI) is constructed for each industry using the total costs data and output index (1997=100) reported by U.S. Bureau of Labor Statistics. Using the total costs data, the total costs index (1997=100) is constructed and then, TUCI(1997=100) is calculated as: (the total costs index*100/output index), Seasonally adjusted.

Implicit price index in U.S. (2002=100), Seasonally adjusted, quarterly, Federal Reserve Bank of Dallas.

Industries included in the study have been shown in the following table.

Industry	**NAICS**
Food manufacturing	311
Animal food manufacturing	3111
Grain and oilseed milling	3112
Sugar and confectionery product manufacturing	3113
Fruit and vegetable preserving and specialty food manufacturing	3114
Dairy product manufacturing	3115
Meat product manufacturing	3116
Bakeries and tortilla manufacturing	3118
Beverage manufacturing	3121
Wineries	31213
Distilleries	31214
Textile mills	313
Fibre, yarn and thread mills	3131
Fabric mills	3132
Fabric mills	3132
Textile and fabric finishing and fabric coating	3133
Textile furnishings mills	3141
Clothing manufacturing	315
Clothing knitting mills	3151
Clothing accessories and other clothing manufacturing	3159
Leather and allied product manufacturing	316
Footwear manufacturing	3162
Other leather and allied product manufacturing	3169
Wood product manufacturing	321
Sawmills and wood preservation	3211
Veneer, plywood and engineered wood product manufacturing	3212
Other wood product manufacturing	3219
Paper manufacturing	322
Pulp mills	32211
Paper mills	32212
Paperboard mills	32213
Converted paper product manufacturing	3222
Printing	32311
Support activities for printing	32312
Petroleum and coal products manufacturing	324
Petroleum refineries	32411
Asphalt paving, roofing and saturated materials manufacturing	32412
Other petroleum and coal products manufacturing	32419
Chemical manufacturing	325
Basic chemical manufacturing	3251
Resin, synthetic rubber, artificial and synthetic fibres and filaments manufacturing	3252
Pesticide, fertilizer and other agricultural chemical manufacturing	3253
Pharmaceutical and medicine manufacturing	3254
Paint, coating and adhesive manufacturing	3255
Soap, cleaning compound and toilet preparation manufacturing	3256
Plastics and rubber products manufacturing	326
Plastic product manufacturing	3261
Unsupported plastic film, sheet and bag manufacturing	32611

Industry	**NAICS**
Plastic pipe, pipe fitting and unsupported profile shape manufacturing	32612
Laminated plastic plate, sheet and shape manufacturing	32613
Polystyrene, urethane and other foam product manufacturing	32614-5
Plastic bottle manufacturing	32616
Other plastic product manufacturing	32619
Tire manufacturing	32621
Other rubber product manufacturing	32629
Nonmetallic mineral product manufacturing	327
Clay product and refractory manufacturing	3271
Glass and glass product manufacturing	3272
Cement and concrete product manufacturing	3273
Lime and gypsum product manufacturing	3274
Primary metal manufacturing	331
Iron and steel mills and ferroalloy manufacturing	3311
Steel product manufacturing from purchased steel	3312
Alumina and aluminum production and processing	3313
Non-ferrous metal (except aluminum) production and processing	3314
Foundries	3315
Fabricated metal product manufacturing	332
Forging and stamping	3321
Cutlery and hand tool manufacturing	3322
Architectural and structural metals manufacturing	3323
Boiler, tank and shipping container manufacturing	3324
Hardware manufacturing	3325
Spring and wire product manufacturing	3326
Machine shops, turned product, and screw, nut and bolt manufacturing	3327
Coating, engraving, heat treating and allied activities	3328
Other fabricated metal product manufacturing	3329
Machinery manufacturing	333
Agricultural implement manufacturing	33311
Construction machinery manufacturing	33312
Mining and oil and gas field machinery manufacturing	33313
Industrial machinery manufacturing	3332
Commercial and service industry machinery manufacturing	3333
Ventilation, heating, air-conditioning and commercial refrigeration equipment	3334
Metalworking machinery manufacturing	3335
Engine, turbine and power transmission equipment manufacturing	3336
Computer and electronic product manufacturing	334
Computer and peripheral equipment manufacturing	3341
Communications equipment manufacturing	3342
Audio and video equipment manufacturing	3343
Semiconductor and other electronic component manufacturing	3344
Navigational, measuring, medical and control instruments manufacturing	3345
Manufacturing and reproducing magnetic and optical media	3346
Electric lighting equipment manufacturing	3351
Household appliance manufacturing	3352
Electrical equipment manufacturing	3353
Transportation equipment manufacturing	336

Industry	**NAICS**
Motor vehicle manufacturing	3361
Motor vehicle body and trailer manufacturing	3362
Motor vehicle parts manufacturing	3363
Aerospace product and parts manufacturing	3364
Railroad rolling stock manufacturing	3365
Ship and boat building	3366
Other transportation equipment manufacturing	3369
Furniture and related product manufacturing	337
Household and institutional furniture and kitchen cabinet manufacturing	3371
Office furniture (including fixtures) manufacturing	3372
Other furniture-related product manufacturing	3379
Other miscellaneous manufacturing	3399

Appendix F

Bootstrap Program in Stata: The Critical Values of the ADF Test Statistics

quietly regress lp lcus lex lw lgdp t

* regress Canadian price on U.S. cost, exchange rate, Canadian wage and GDP as well as trend using the original data set. All variables are in logarithm form.

predict resid, residuals

* find the residuals from the above regression.

set obs n

* determine the number of observations.

gen ep1 = invnorm(uniform())*(The Standard Deviation of lp)

* create n random observations from a normal distribution with mean 0 and variance of lp (dependent variable).

gen ep2 = invnorm(uniform())*(The Standard Deviation of lcus)

gen ep3 = invnorm(uniform())*(The Standard Deviation of lex)

gen ep4 = invnorm(uniform())*(The Standard Deviation of lw)

gen ep5 = invnorm(uniform())*(The Standard Deviation of lgdp)

tsset t

* define the time variable.

gen lphat = intercept+ l.lp+ ep1

* create a new sample for lp based on an unit root process. Intercept is the mean of the first difference of lp across sample. l.lp is the first lag of lp.

gen lcushat = intercept+ l.lcus+ ep2

gen lexhat = intercept+ l.lex+ ep3

gen lwhat = intercept+ l.lw+ ep4

gen lgdphat = intercept+ l.lgdp+ ep5

capture program drop adfcv

* start the simulation program to find the critical values for ADF test.

program adfcv, rclass

drop ep1 ep2 ep3 ep4 ep5 lphat lcushat lexhat lwhat lgdphat resid

* delete these variables to be able to create them again for the next round of regressions.

```
set obs n
gen ep1 = invnorm(uniform())*(The Standard Deviation of lp)
gen ep2 = invnorm(uniform())*(The Standard Deviation of lcus)
gen ep3 = invnorm(uniform())*(The Standard Deviation of lex)
gen ep4 = invnorm(uniform())*(The Standard Deviation of lw)
gen ep5 = invnorm(uniform())*(The Standard Deviation of lgdp)
tsset t
gen lphat = intercept+ l.lp+ ep1
gen lcushat = intercept+ l.lcus+ ep2
gen lexhat = intercept+ l.lex+ ep3
gen lwhat = intercept+ l.lw+ ep4
gen lgdphat = intercept+ l.lgdp+ ep5
quietly reg lphat lcushat lexhat lwhat lgdphat t
* do the regression using the new sample for the dependent and explanatory variables.
predict resid, residuals
reg d.resid l.resid l.d.resid, noconstant
* regress the first difference of residuals on its lags[1] as well as the lag of residuals without constant.
return scalar contime = (_b[l.resid]/_se[l.resid])
* find the ADF test statistics in each round of regressions.
end
simulate “adfcv”contime = r(contime), reps(1000)
* repet the program for 1000 times.
sort contime
display contime[100]
* report the critical value at 10 percent significance level.
display contime[50]
* report the critical value at 5 percent significance level.
display contime[10]
* report the critical value at 1 percent significance level.
```

[1]The ADF test statistics for the residuals of the original data set have been obtained using EViews software. EViews determines the number of lags automatically based on the AIC. In simulation program which has been written in Stata, I have chosen the number of lags based on the reported lag length by Eviews.

As the reported critical values in Table D.1 indicate, the bootstrapped critical values are a little different from the critical values reported by Maddala and Kim (1998). This difference might be the consequence of the following reasons: (1) Here, the created random variables, which are used to create different samples for each variable, have the mean equal to zero and the variance equal to the variance of the related variable in the original sample (for example, gen ep1 =invnorm(uniform())*(The Standard Deviation of lp)). However, in the general simulation by MacKinnon (1991), the random variables have the mean equal to zero and the variance equal to one. (2) Here, the unit root process is specified with intercept (for example, gen lphat = intercept+ l.lp+ ep1), while MacKinnon (1991) specifies the unit root process without the intercept. (3) To find the ADF test statistics, we also include the lags of the dependent variable in the model based on the AIC, while they are not considered by MacKinnon (1991) (Cheung and Lai, 1995).